THE UNIVERSITY OF ALBERTA

PRODUCTION EFFICIENCY IN ALBERTA BEEF FEEDLOTS

by

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The undersigned certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled "Production Efficiency in Alberta Beef Feedlots," submitted by O. Glenn Dawson in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

The Canadian demand for beef is expected to increase sharply in the next ten years in response to a rising population and an upward trend in per capita beef consumption. Alberta feedlot operators are expected to make a substantial contribution in meeting this demand.

Alberta's beef feedlot industry is presently experiencing a market price squeeze caused by the demand for feeder cattle exceeding the demand for slaughter animals. To combat this situation feedlot operators will need to increase their production efficiency.

This thesis is an inquiry into the effects of feedlot size and rate of utilization on the total nonfeed costs of feedlot operation. A survey of Alberta feedlots was made to obtain the relevant cost and size data. The results of the analysis suggest alternative methods available to feedlot operators for increasing their production efficiency. These alternatives have policy implications for future expansion and location of the Alberta feedlot industry.

The extent to which Alberta feedlot operators can increase their production efficiency is limited by the availability of capital for feedlot expansion and operating money. The latter is of vital importance in increasing the feedlot utilization rate which is the most important factor in decreasing the average cost of production.

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Meat is Canada's largest food industry. In 1968 sales of livestock accounted for 32.1 percent of the total farm cash receipts. Receipts from wheat were 21.1 percent of the total, dairy products, 17.1 percent; and poultry and eggs, 8.9 percent [14].

In 1968 per capita consumption of meats in Canada reached an all time high of 198.8 pounds, accounting for approximately one third of the consumers' total food expenditure. Consumer purchases of beef represented a major portion of the increased consumption by establishing a new record of 86.8 pounds per capita. All other meats and poultry, with the exception of mutton and lamb, declined slightly from their 1967 consumption levels [14]. Table 1 presents the 1960-1968 data on Canadian per capita consumption. Because the population of Canada increased steadily throughout this period, these data indicate an annual increase in the total meat consumption, with beef showing the greater rate of increase.

The Canadian demand for beef is expected to continue to increase at the rate of 3 to 4 percent per year [12]. A similar increase in the supply of Canadian beef has been projected by Love [10]. He predicted that Canada's beef production will increase by 50.9 percent over the 1965 to 1980 period and that Alberta's annual slaughter cattle production will increase by 93.5 percent for this same period. Alberta is presently the leading beef producing province in Canada with 37.5 percent of the nation's

Table 1

CANADIAN PER CAPITA MEAT CONSUMPTION 1960 to 1968

Item	1960	1961	1962	1963	1964	1965	1966	1967	1968
Beef	70.0	70.5	71.1	74.3	79.4	83.6	84.1	84.0	86.8
Pork	52.6	50.3	50.1	50.7	51.8	47.9	46.9	53.8	53.6
Veal	6.9	6.8	7.1	6.5	7.2	8.3	7.0	7.2	6.4
Mutton & Lamb	2.9	3.5	3.8	4.0	3.4	2.8	3.4	3.6	4.2
Variety Meats	4.8	4.5	4.3	4.0	3.9	3.6	3.6	3.9	3.8
Canned Meats	6.4	4.3	4.2	4.4	4.5	4.2	4.2	4.7	4.3
Poultry	27.8	31.1	31.0	32.5	34.5	36.0	39.4	40.7	39.7
Total	171.4	171.0	171.6	176.4	184.7	186.4	188.6	197.9	198.8

Source: Meat Packers Council of Canada. Islington, Ontario: Meat Packers of Canada, 1969-70.

total beef cattle population.

The general increase in beef consumption recorded over the eight year period from 1960 to 1968 has largely been in response to a similar trend in consumer incomes. Relative to other foods beef has a high income elasticity (-.95) [4] and a slightly inelastic demand (-.6441) [5]. As the price of beef increases by a given percentage, the quantity consumed decreases but less than proportionately. Should incomes increase at a more rapid rate than beef prices, consumers will tend to increase their purchases of beef, provided other determinants of demand do not offset these forces. These factors include the quality of beef relative to other meats, as well as the price relatives in the market. Beef must compete with all other meats for the consumer's food dollar.

The competitive nature of meats in the marketplace has been a prime factor in promoting quality and price improvements in the meat industry. Price improvements have been relative to other food items, rather than in the form of reductions. Quality improvements, on the other hand, have been real in terms of consumer demand. These improvements have been made possible through grading standards and production practices, resulting in a more uniform and desirable product.

Quality and price improvements in the beef industry have necessitated many important organizational changes in production practices. Like other segments of the agricultural economy, the beef industry has been experiencing rapid technological advances, increasing production costs, and narrowing profit margins. In an effort to maintain their net farm income, producers have been forced into either increasing their production

efficiency or leaving the industry in favor of more lucrative forms of agricultural production. Many cattlemen have left the agricultural sector of the economy entirely. The result has been a trend toward fewer, but larger, producing units and specialization at each stage of the production cycle. These changes have not, to any significant degree, affected the overall structure of the beef industry; its structure remains one of numerous producers, each making a relatively small contribution to the industry's annual output. However, specialization of large producers at the stage levels of the production sequence has profoundly affected the organization of production in the beef industry.

The organization of production in the beef industry involves three important considerations: (1) the type of production, (2) the location of the producing unit, and (3) the size of the enterprise. Competition for resources within agriculture and the need for greater production efficiency have resulted in the disintegration of an almost entirely vertically integrated beef producing industry. Years ago, when cattle were first introduced to Alberta, beef production was a range-oriented industry. Cattlemen maintained the basic cowherds, produced calves, and marketed three to four year old "grass-fat" slaughter animals directly from the range.

Beef production, with the exception of the cow-calf enterprise, is no longer a range-oriented industry. The change in consumer demand for more highly finished cuts of beef necessitated the use of high energy rations under confinement conditions to attain the desired carcass quality. The lack of available feed grains in the range-producing regions

prevented these areas from finishing cattle to slaughter weights. Feeder cattle moved from the range to the grain-producing regions of the province for fattening. Competition for resources within agriculture has stimulated further separation of the beef industry into specific types of production.

Types of Beef Production

Beef production can be described as the flow of cattle through various stages of a production cycle, originating with the birth of calves and culminating with the eventual slaughter of all animals surviving their respective stages of production. This production flow has been shown diagrammatically in Figure 1; the direction of flow is indicated by arrows. Animals may move directly toward the packing house, or indirectly through primary production, feeder production, or feedlots depending on the purpose for which they are selected.

The primary beef producing enterprises consist of three increasingly distinct types of production: (1) the production of purebred cattle, (2) commercial beef production, and (3) dairy production. The contribution of each to the annual output of beef is in the form of calves, cull cows, and bulls. Only the commercial enterprises can be considered as producing specifically for the slaughter market; however, the contribution of the other primary producers, although secondary in nature, is significant.

There were approximately 215,000 producing dairy cows in Alberta in 1968 [1]. Assuming an 80 percent calf crop and 20 percent culling rate, the dairy industry would have produced 172,000 calves, of which 145,000 could be expected to have entered the flow of beef production. As was indicated by Figure 1, dairy calves may flow directly to the packing house

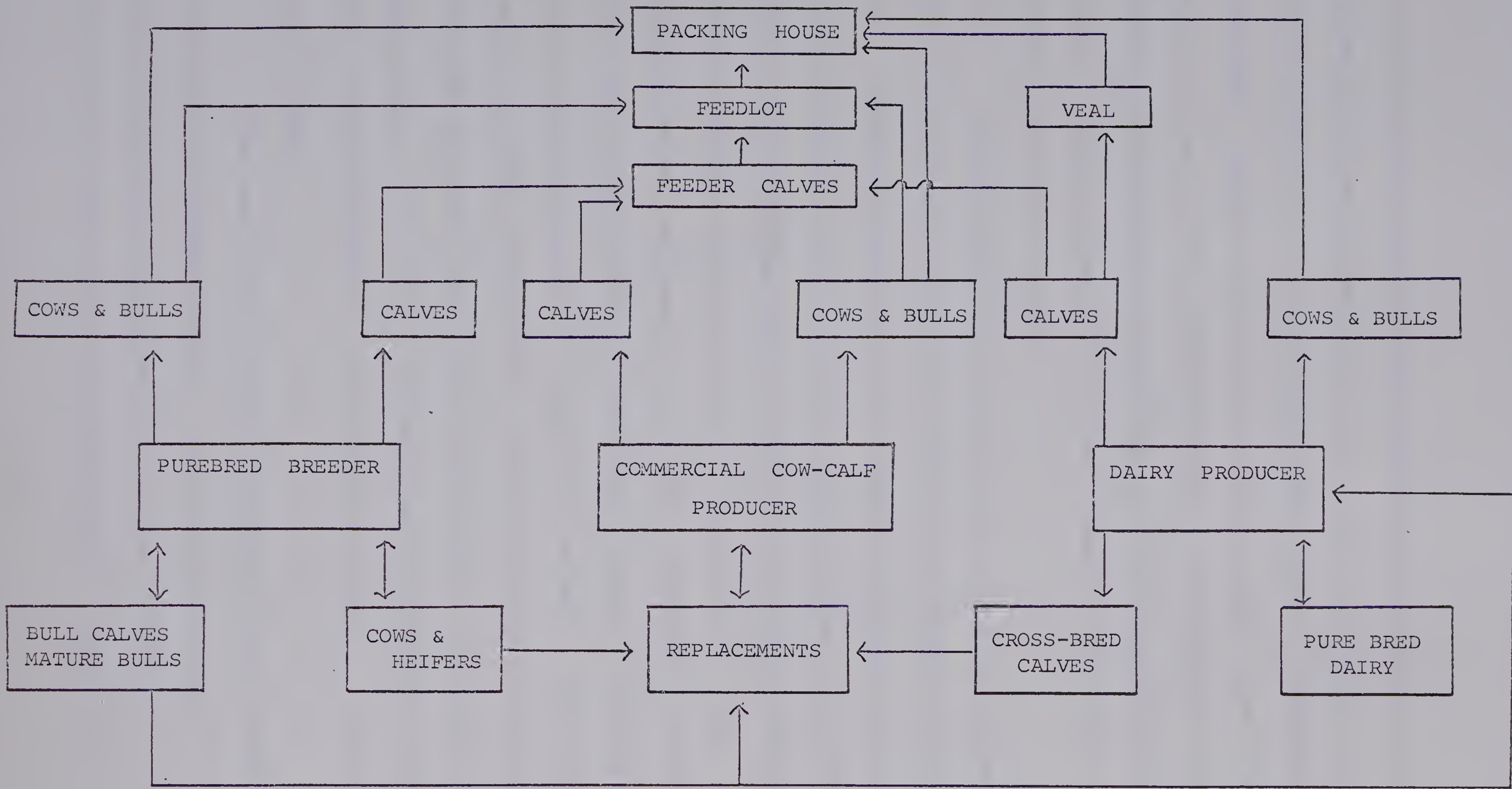


Figure 1

FLOW DIAGRAM OF BEEF PRODUCTION

as veal or go into feeder cattle production, into feedlots, and then to packing plants as finished beef animals. The dairy industry also produces crossbred calves to be used as replacement animals in commercial cattle operations. However, this flow is relatively small at the present time and is in a more or less experimental stage of development. Commercial cattlemen are interested in improving the milking capacity of the beef animal; crossbred calves from the dairy industry could make a significant contribution in this respect.

Purebred beef cattle production is also a specialized type of production with only a secondary interest in supplying beef for consumption. The major contribution of the purebred producer is the development and improvement of the beef animal. Although often criticized for their efforts, the purebred breeders do hold a key to future improvements in the beef animals and the development of new breeds of cattle. The latter necessitates the maintenance of pure lines that may be crossbred with other pure lines, and then through a complicated system of breeding and selection result in the development of superior beef animals. Those animals not meeting selection standards are culled from the flow of replacement cattle and enter the direct flow of beef animals toward the slaughtering plants. These flows, as indicated by Figure 1, may involve other primary producers, feeder cattle producers, or feedlot operators prior to culminating at the packing house.

The commercial cow-calf enterprise is often thought of as the foundation of the beef industry. It is the basic element of the beef industry, providing a vast majority of the cows and calves that enter the flow of beef animals toward the packing house. These flows, as depicted in

Figure 1, involve replacement cattle to be retained in commercial production and the direct flows of calves, cull cows, and bulls toward the packing house.

Location of Beef Production

The second factor to be considered in the organization of beef production is the location of the producing unit. Location, as it applies to any industry, is largely determined by the supply and price of the factors of production and the availability of markets. In the beef industry one finds dairy producers in close proximity to urban areas, commercial cow-calf and purebred producers centered in range and mixed farming areas, and feedlot producers centralized in the grain producing regions around packing centers. This general location pattern has evolved through competition for resources within agriculture, especially for land and thus relates to the general rate of return of each type of production.

The cow-calf enterprise is dependent on a supply of relatively inexpensive forage for its existence. Competition between forage and grain production for available land has resulted in the former being located in areas of either rough terrain or insufficient rainfall to make grain production profitable. These areas are located in the eastern and southern portions of the province, along the foothills region, and dispersed throughout mixed farming centers.

Purebred cattle production has a similar resource requirement as commercial production and thus is distributed in approximately the same areas. Dairy production, on the other hand, has been able to compete with grain production for those land areas in close proximity to urban centers.

The perishable nature of milk production in past years is largely responsible for the present location of dairy production. Modern transportation and handling techniques necessitate a centralization of the dairy industry in order that milk assembly costs may be minimized; however, production does not need to be carried out in the immediate vicinity of the urban centers. The relative importance of each of the census divisions of the province in beef and dairy production is indicated by Table 2. These divisions have been superimposed on Figure 2 to show their locations with respect to other divisions and urban centers within the province. The data indicate the potential calf production of each area in 1966.

Transportation costs have been a major factor in establishing the beef feedlot industry of Alberta in those areas with abundant feed grain supplies adjacent to packing centers. This type of production is not land-based and therefore can compete with other forms of agricultural production for the relatively expensive lands surrounding urban centers. Beef feedlot operations are dispersed throughout the province; however, most are located within the triangular zone indicated on Figure 2. Within this zone the intensity of cattle feeding increases as the distance to packing centers decreases.

Size of the Beef Producing Enterprise

The size of the business enterprise significantly affects the firm's overall production efficiency. Examination of census data indicates that Alberta's total beef production has increased, while the number of producers involved in this production has decreased. Several reasons could be cited for this trend to larger producing units; increasing production

Table 2

DISTRIBUTION OF ALBERTA BEEF AND DAIRY COWS, 1966

Census Division	Beef Cows	Dairy Cows	Beef and Dairy Cows
1	66,094	4,169	70,263
2	97,245	12,182	109,427
3	91,465	5,493	96,958
4	90,993	2,478	93,471
5	66,952	5,692	72,644
6	120,679	19,089	139,768
7	117,533	13,325	130,858
8	98,548	30,086	128,634
9	8,217	467	8,684
10	123,061	39,606	162,667
11	63,680	53,793	117,473
12	45,785	16,076	61,861
13	67,860	27,858	95,718
14	11,247	3,576	14,823
15	49,708	9,081	58,789
Total	1,119,067	242,971	1,362,038

Source: Canada Dominion Bureau of Statistics, Census of Agriculture 1966 (Ottawa: DBS, 1966).

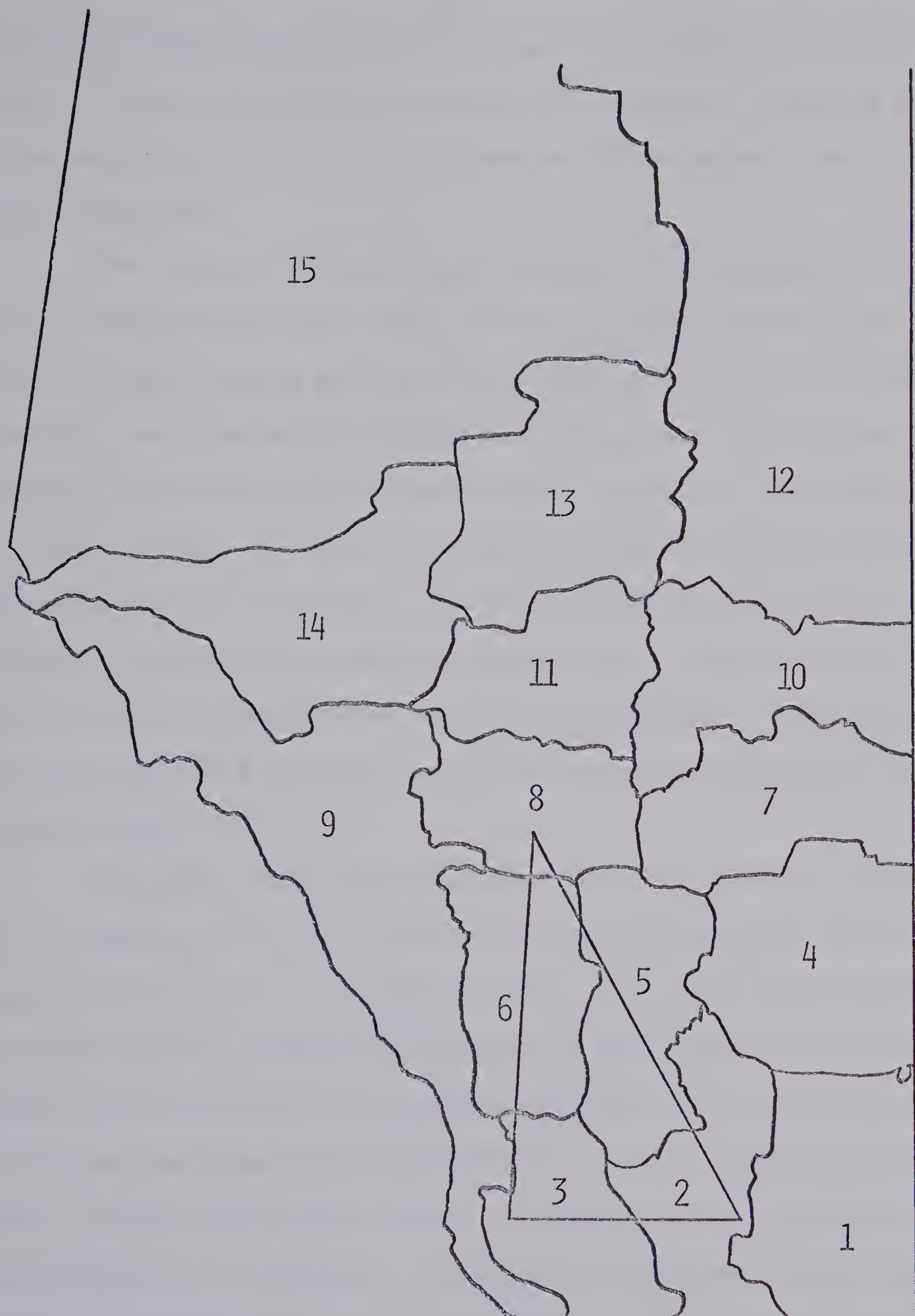


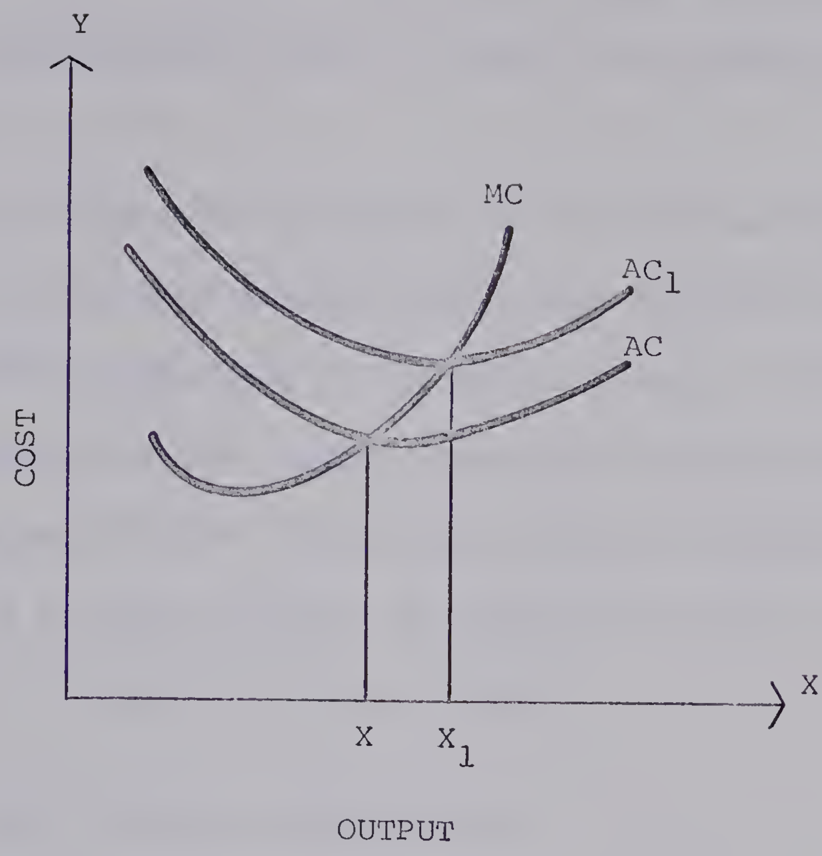
Figure 2

CENSUS DIVISIONS OF ALBERTA AND LOCATION OF THE MAJOR CATTLE FEEDING REGION

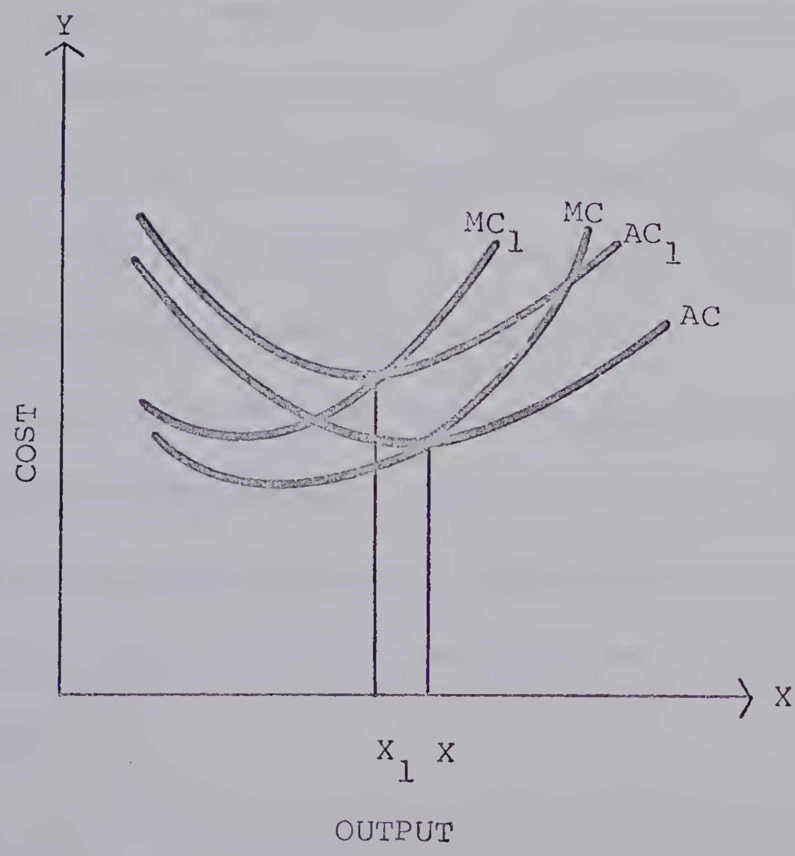
costs and declining profits per unit of output are among the more important factors. To maintain operator net incomes in the face of declining profit margins per unit of output, the cattleman has had to adjust toward a larger business enterprise.

Cost increases in beef production have been essentially of two types: (1) increasing fixed costs and (2) increasing variable costs. The effects of these costs on production efficiency are to a certain degree offsetting. As fixed costs increase, the average cost of production increases, thus shifting the minimum average cost point to the right. This shift increases the level of output that must be attained if the average cost is to be minimized. Increasing variable costs result in an upward shift of both the average and marginal costs, causing a shift to the left of the point of minimum per unit cost of production. These situations have been illustrated in Figure 3 with subscripts representing the increased cost conditions.

The major portion of the costs of beef production are variable costs. Excluding the cost of cattle, feed alone accounts for 60 to 70 percent of the total cost of production [8]. Feed prices have generally increased, however; technological advances in feed formulation and feeding methods have improved feed efficiency, resulting in only minor changes in the feed cost per pound of beef production. A general substitution of capital for labor has further reduced the effects of price increases in the variable factors of production. Therefore, the adjustment towards higher levels of beef production per producing unit can be explained partially by the effects of increasing fixed costs as indicated by Figure 3. This type



Increased Fixed Cost



Increased Variable Cost

Figure 3

THE EFFECT OF INCREASING FIXED AND VARIABLE COSTS OF THE MINIMUM AVERAGE COST OF PRODUCTION

of adjustment results in more intensive production; further increases in the size of the beef enterprise have been the result of economies of larger producing units.

Many studies of farm size have been made for various enterprises and locations. In the beef industry these have largely centered around cow-calf and feedlot operations in the United States. The Canada Department of Agriculture found that profits generally increase with an increase in size of business within a production system on ranches in southern Alberta [7]. A detailed analysis of economies of size relationships will be presented in Chapter IV of this study.

Beef Marketing Organization

Marketing consists of those economic activities necessary to accomplish the flow of goods and services from the producer to the consumer [9]. In the beef industry these activities perform the assembly, processing, distribution, and exchange functions of the market channel responsible for accomplishing the flow of animals through the various stages of the production sequence of Figure 1. The organization of these functions has implications for beef marketing efficiency.

Beef marketing has two organizational dimensions: (1) functional organization and (2) spatial organization. The former involves the market channel. Spatial organization deals with the origins and destinations as well as the transportation modes and facilities utilized in the assembly and distribution of cattle.

Functional Organization

The movement of animals through the stages of production involves

numerous agencies acting to facilitate the flow of cattle. These agencies include the terminal and auction markets, commission firms, packer buyers, and a variety of order buyers and dealers. Each performs a function; although their activities do often overlap, resulting in market inefficiencies. Transactions in the market must add sufficient value to the product to offset their cost or they are undesirable from both producer and consumer points of view. The trend to direct marketing of feeder and slaughter cattle is an attempt to reduce total marketing costs by reducing the number of transactions required to accomplish the marketing function.

Direct marketing of feeder cattle, although not so prevalent in Canada as in the United States, is becoming more popular as producers realize the need to merchandise their animals [16]. Direct marketing of slaughter cattle is a common practice. These changes in marketing preference have come at the expense of the terminal markets. During the ten year period from 1958 to 1967, Alberta terminal markets' share of the total cattle marketing decreased from 63.9 percent to 37.3 percent, while auction markets increased their share from 12.6 percent to 29.8 percent, and direct marketing increased from 23.5 percent to 32.9 percent [13]. There is every indication that this trend will continue.

Terminal markets provide facilities for receiving, weighing, caring, handling, and selling livestock. In Alberta these facilities are owned by stockyard companies, and the actual selling of cattle takes place in the auction ring. Cattle are weighed just prior to, or immediately upon, leaving the auction ring. Commission firms, acting on behalf of both buyers and sellers, facilitate the transfer of ownership of livestock. The

terminal markets' decreased share of the total marketing of cattle in Alberta has lessened its role as the livestock exchange and vehicle for establishing cattle market prices. Table 3 shows the distribution of Alberta cattle and calves marketed through terminal and auction markets, and direct purchases by packers in the province from 1958 to 1967.

There were three terminal markets operating in Alberta in 1968, located at Edmonton, Calgary, and Lethbridge. During this same period a total of 54 class D or regular auction markets were reported in operation. These markets are located in most of the major country trading centers throughout the province. The operation of auction markets is similar to terminal markets in that cattle are offered for sale simultaneously to several prospective buyers and are sold in the ring to the highest bidder. The facilities of auction markets are privately owned, and commission firms are not involved in the selling and transfer of cattle. The auction firm charges a fee for services performed either on a per head or commission basis.

The Alberta Department of Agriculture annual report for 1968 states that 867 livestock dealers and agents were licensed to operate in the province in that year [2]. Dealers are independent operators who buy and sell livestock for a profit. They purchase cattle from producers, auction, and terminal markets and sell directly to packers, terminal markets, or other auction markets. Their actions are dependent on price spreads between markets. Agents, on the other hand, are usually packer representatives, but may also act for producers, feeder associations, or other markets. Their function is primarily to fill orders for their clients or

Table 3

LIVESTOCK HANDLED BY COUNTRY AUCTIONS AND TERMINAL MARKETS AND PURCHASED DIRECTLY BY PACKERS, ALBERTA, 1956-1967

	Cattle and Calves									
	Country Auctions				Terminal Markets				Direct to Packers	Grand Total
Year	Feeder	Slaughter	Calves	Total	Feeder	Slaughter	Calves	Total		
					(number of head)					
1956	50,986		13,371	64,357	152,359	357,488	73,913	583,760	234,284	882,401
1957	73,634		28,209	101,843	138,111	396,118	97,708	631,937	276,485	1,010,265
1958	81,029	10,502	39,977	131,508	167,020	360,495	136,685	664,200	244,583	1,040,291
1959	92,906	15,889	53,682	164,477	156,983	315,489	108,556	581,028	243,188	988,693
1960	164,119	20,609	80,884	276,612	139,597	359,995	90,862	590,454	293,203	1,160,269
1961	180,982	57,698	111,340	350,020	151,503	333,204	122,390	607,097	377,089	1,334,206
1962	217,519	44,613	134,668	396,800	178,866	324,886	147,450	651,202	374,436	1,422,508
1963	232,845	53,569	160,227	446,641	185,807	290,347	123,729	599,883	418,542	1,442,976
1964	273,717	47,559	150,732	472,008	197,704	318,047	125,383	641,134	499,429	1,612,571
1965	307,028	30,438	182,668	520,134	262,751	365,025	176,920	804,696	559,567	1,884,397
1966	372,502	26,874	171,896	571,272	245,372	398,903	163,700	807,975	602,371	1,981,618
1967	413,485	23,544	151,139	588,168	221,183	348,074	166,882	736,139	651,153	1,975,460

Source: Curtis E. McIntosh. "A Statistical Analysis of Cattle Prices on Terminal and Auction Markets in Alberta" (unpublished MSc. Thesis, University of Alberta, Department of Agricultural Economics 1968) p. 35.

employers. Packer buyers are but one type of livestock agent assisting in the direct marketing of cattle.

Direct marketing is a method of selling. It is completed between the buyer and the seller without the support of a commission firm or marketing organization. The term specifically applies to producer sales of livestock to packers. Direct marketing of cattle has been increasing because of the need to eliminate middlemen in the marketing channel. Direct marketing also offers greater convenience and the ability to bargain for price and shrink prior to moving the cattle.

The market organization of the beef industry is illustrated in Figure 4. This flow diagram indicates the qualitative and quantitative movements of cattle between economic entities in the market. The relative share of the market has not been shown for direct marketing of feeder cattle or the livestock dealers. A lack of information concerning these markets prevents anything more than a generalization of their importance. Therefore, the total marketings depicted in Figure 4 have been based on the 1967 livestock marketings shown in Table 3. The importance of the country auction market in the marketing of feeder cattle can be attributed to its proximity to the source of feeder cattle and its policy of catering to special feeder cattle sales. The auction market's location with respect to feedlots has also been a factor in the growth of auction marketing of feeder cattle.

Spatial Organization

Cattle are produced and marketed in all census divisions of the province; however, certain regions are noted for their marketing of feeder

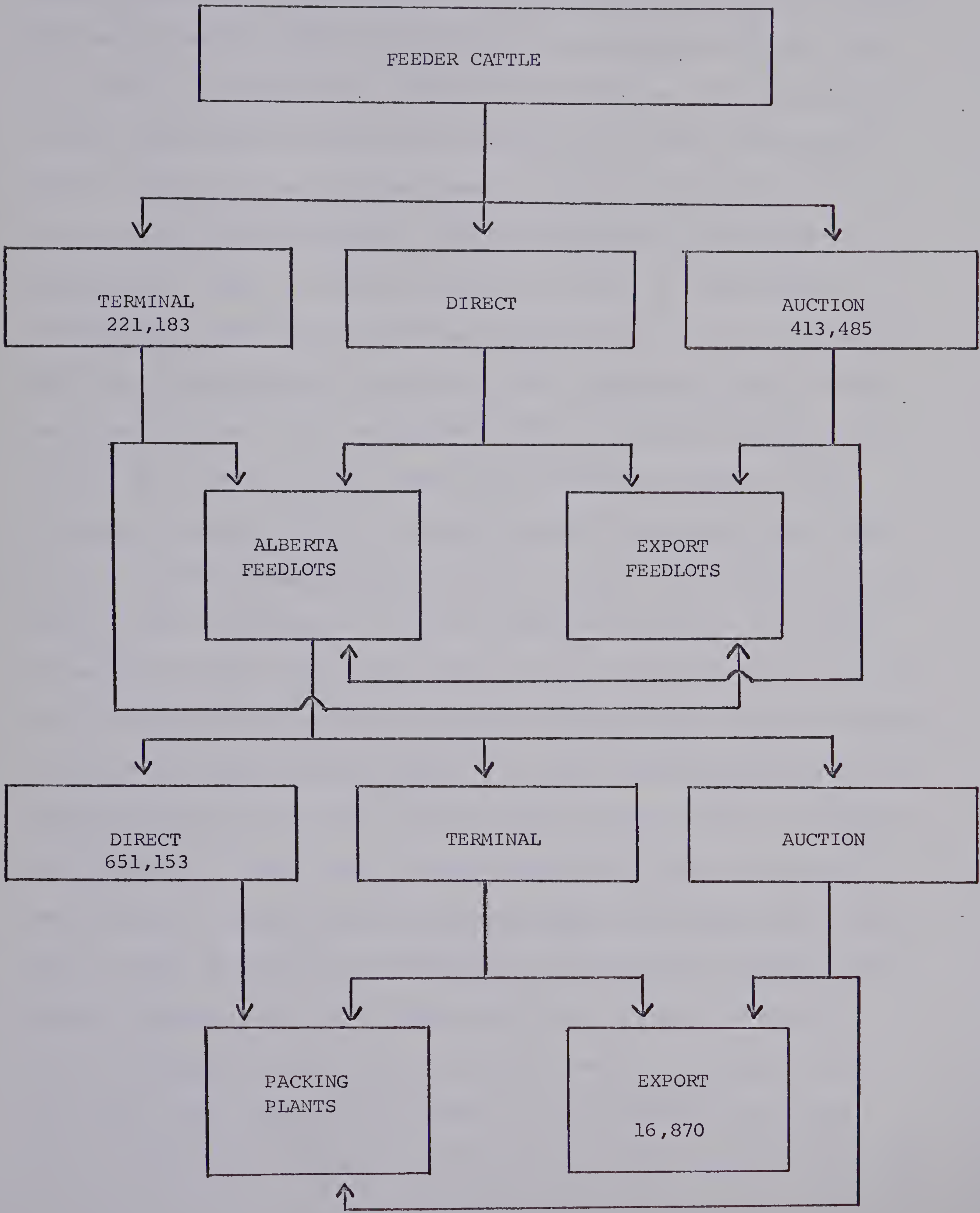


Figure 4

MARKET ORGANIZATION OF THE ALBERTA CATTLE INDUSTRY (1967)

cattle, while other regions dominate in the marketing of slaughter animals. The general feeding region of the province was outlined in Figure 2, and it is from this region that a majority of the slaughter cattle originate. A lack of information on the direct marketing and auction marketing of feeder cattle by census divisions prevents meaningful delineation of feeder cattle marketing regions. Some generalizations can be made in regard to the number of beef cows reported on farms in 1966 (Table 2). In descending order of cows on farms, Census Divisions 10, 6, 8, 2, and 4 were the leading producers of calves in 1966. According to the terminal marketing of feeder cattle during 1968 (Table 4) Census Divisions 11, 6, 10, 13, and 12 were the major feeder cattle marketing regions of the province. Assuming production remained constant during the 1966 to 1968 period, the following generalizations can be made: (1) The more southerly regions (Census Divisions 2, 4, and 8) preferred the direct or auction marketing of feeder cattle; (2) northern regions (Census Divisions 11, 12, and 13) preferred the terminal marketing of feeder cattle. These statements are possible to make because regions 2, 4, and 8 were leading producers of calves but did not hold their position in the terminal market. Similarly divisions 11, 12, and 13 were not major producing regions but appeared among the five leading terminal marketing regions for feeder cattle sales. Table 5 shows the origins and destinations of cattle sold through Alberta terminal markets during 1968. These data do not indicate the origins of cattle according to their classifications as feeder or slaughter cattle and calves. Few comments can be made as to the relative size of each region with respect to their marketings of the various classifications or

Table 4

ALBERTA CATTLE MARKETINGS BY CENSUS DIVISION 1968

(Marketed at stockyards and shipped directly to plants.)

Census Division	Steers	Heifers	Cows	Bulls	Feeders	Total
1	13,947	13,466	12,308	905	2,502	43,128
2	104,030	57,302	18,990	1,292	11,875	193,489
3	33,946	17,665	14,439	920	8,309	75,279
4	4,240	3,791	5,102	536	4,815	18,484
5	42,114	26,035	9,931	889	15,489	94,458
6	96,835	54,944	28,761	2,579	35,158	218,277
7	34,379	21,024	13,410	1,191	15,049	85,053
8	81,289	39,204	17,468	1,226	10,914	150,101
9	57	17	20	3	45	142
10	40,069	23,468	21,507	1,905	31,697	118,646
11	53,059	23,275	26,912	1,959	35,573	140,778
12	4,943	3,400	7,240	683	18,349	34,615
13	21,679	11,506	14,228	1,242	25,628	74,283
14	735	533	1,350	120	4,050	6,788
15	6,602	4,537	6,888	623	10,165	28,815
Total	537,924	300,167	198,554	16,073	229,618	1,282,336

Source: Data published in Canada Department of Agriculture, Annual Livestock Marketing Review, 1968.

Table 5

ORIGIN AND DISPOSITION OF CATTLE SALES ON ALBERTA TERMINAL MARKETS - 1968

Census Division	EDMONTON Origin Cattle	EDMONTON Origin Calves	EDMONTON Disposition Cattle	EDMONTON Disposition Calves	CALGARY Origin Cattle	CALGARY Origin Calves	CALGARY Disposition Cattle	CALGARY Disposition Calves	LETHBRIDGE Origin Cattle	LETHBRIDGE Origin Calves	LETHBRIDGE Disposition Cattle	LETHBRIDGE Disposition Calves	TOTAL Origin	TOTAL Disposition
1					363	138	592	710	3,614	1,842	413	172	5,957	1,887
2	59	55	16,898	4,817	6,404	1,045	11,073	2,488	23,023	6,151	15,340	9,284	36,737	59,900
3	30		1,214	878	13,027	1,568	2,202	1,737	7,946	2,996	3,893	2,063	25,567	11,987
4	209	39	522	116	12,916	5,936	87	459	133				19,233	1,184
5			1,572	976	67,728	11,583	11,197	6,930	824	443	236	148	80,578	21,059
6	61	60	5,073	3,891	161,490	22,879	41,385	28,948					184,490	79,297
7	23,964	6,907	12,453	4,025	12,625	3,504	8	95	7	15			47,022	16,581
8	4,351	734	26,473	11,073	33,702	5,786	1,973	1,761	42	42			44,657	41,280
9					141								141	
10	53,860	24,318	15,994	6,259	553	100	20						78,831	22,273
11	66,308	19,520	31,982	14,759	100	80					88	41	86,008	46,870
12	27,856	17,508	2,715	1,416									45,364	4,131
13	46,422	18,113	10,871	3,510									64,535	14,381
14	5,950	3,989	935	454									9,939	1,389
15	18,270	7,217	1,098	581	13	14							25,514	1,679
Adjustment*		2,142											2,142	
Total Alberta	247,340	100,602	127,800	52,755	309,062	52,633	68,537	43,128	35,589	11,489	19,970	11,708	756,715	323,898

Table 5 (continued)

Province	EDMONTON Origin		EDMONTON Disposition		CALGARY Origin		CALGARY Disposition		LETHBRIDGE Origin		LETHBRIDGE Disposition		TOTAL Origin	TOTAL Disposition
	Cattle	Calves	Cattle	Calves	Cattle	Calves	Cattle	Calves	Cattle	Calves	Cattle	Calves		
Alberta	247,340	100,602	127,800	52,755	309,062	52,633	68,537	43,128	35,589	11,489	19,970	11,708	756,715	323,898
B.C.	4,826	1,079	859	558	1,932	633			753	612	33		9,835	1,450
Sask.	1,396	711	1,750	136	366	215	62	121	511	223	50	56	3,422	2,175
Man.							84	269						353
Ont.			4,703	18,873			2,253	5,390			562	488		32,269
P.Q.			42											42
Other Yards	10		938**		248	14	547		1,188	223			1,683	1,485
Edm. Plants	2,079	706											2,785	
Export			1433**				15,612	576			1,258	207		19,086
Slaughter			148,902**				224,513	4,011			16,168	88		393,682
Total	255,651	103,098	358,749		311,608	53,495	311,608	53,495	38,041	12,547	38,041	12,547	774,440	774,440

* Edmonton total was adjusted in order to balance receipts and disposition

** Edmonton disposition reported as cattle and calves.

Source: Canada Department of Agriculture Livestock Market Reports, 1968.

grades of cattle. The most significant information obtained from Table 5 is the destinations of feeder cattle sold through the three Alberta terminal markets. Appendix Tables A and B indicate the provincial trend from 1964 to 1968 in cattle and calf marketings and the percentage distribution for each. Because similar data are unavailable for auction markets in the province, these tables serve only as indications of marketing trends.

In general, the Alberta cattle market involves a flow of feeder cattle from the shortgrass range area (Census Divisions 1, 2, and 4), the foothills region (Census Divisions 3 and 6), and the central regions (Census Divisions 10, 11, 12, and 13) into the feeding regions (parts of Census Divisions 2, 3, 5, and 6). Slaughter cattle move from the feeding regions to packing plants at Edmonton, Red Deer, Calgary, Lethbridge, and Medicine Hat. During 1968 the feeding regions accounted for approximately 45 percent of the cattle sold through terminal markets and shipped directly to plants in Alberta. There is also, within the province, a considerable inter-regional flow of animals sold as feeders and purchased to be fed to slaughter weights within the same region. This type of marketing is almost completely through auction markets.

Beef Feedlot Operations

The lack of information relating to beef feedlot operation in Alberta has been recognized for several years. Some of the information cited as being needed includes: (1) The importance of the rate of feedlot utilization in determining the cost per animal fed, and (2) the relationship between feedlot size and the nonfeed costs of production. The purpose

of this study was to analyze these economic aspects of beef feedlot operation and to determine the size and rate of utilization compatible with least cost operation.

The beef feeding industry of Alberta consists of both farm and nonfarm feedlot operations. Farm feedlots range from small supplementary enterprises using surplus feed grains and off-season idle labor to relatively large feedlots that provide the major source of farm income. The latter most often form part of an integrated cow-calf or cropping enterprise. Nonfarm feedlots are specialized cattle feeding operations that purchase all of their feed requirements—either purchasing feeder cattle or custom-feeding cattle for private businessmen or producers on a fee basis. The characteristics of feedlots are similar and so are the feeding systems used; the distinction among types of feedlots is made in terms of size and facilities used.

The growth of the Alberta feedlot industry has paralleled the growth in beef cattle slaughtering in the province. The high cost of transporting finished slaughter cattle to packing plants outside the province has resulted in relatively few animals being fed in Alberta and slaughtered in other areas. Alberta feedlot industry statistics are not systematically correct (example: number of cattle on feed in the province). The cattle marketing data presented in Table 3 were used in the present study. Some additional information is available [10].

Types of Feedlots

Alberta feedlots vary in size from small farm enterprises to large custom feedlots. The smallest farm feedlots, with capacities of

less than 100 cattle, are highly labor intensive. Cattle are confined to pens and are hand fed concentrate rations in bunks located within the pen. Roughage is also hand fed in fenceline mangers. As the number of cattle fed increases, the self-feeding of concentrates replaces the hand feeding method. This method results in considerable labor saving; however, it does limit the producer's control over daily feed intake, and the concentrate portion of the ration can only be changed when the feeder is empty. Relatively few Alberta feedlots with capacities in excess of 1,000 cattle use the self-feeding method. Instead they rely on fenceline bunk feeders that can be used for both the concentrate and the roughage portions of the rations fed.

Fenceline bunk feeding of cattle has several advantages over all other feeding methods. The feeder is able to control the daily forage and grain content of the ration, as well as the daily consumption by the animals. In this way cattle may be fed according to the availability of feedstuffs and the rate of gain desired. The latter is most important when cattle are being fed to reach market weights at a particular time. In other words, the producer may wish to market his cattle during the month of June; however, if he were to use the self-feeding method the animals would be overweight by that time and would be discounted heavily. The month of marketing is an important consideration in cattle feeding due to price fluctuations. Therefore, the feedlot operator who is able to control the rate of gain may realize greater profits.

Feedlot Construction and Facilities

Cattle feedlots in Alberta consist of a system of corrals or

pens for confining and handling cattle and some type of shelters or windbreaks. The type of construction used for these facilities varies with the age and size of the feedlot. With the exception of the relatively new, larger feedlots the most commonly used materials have been wooden posts and slabs or planks for corrals and wooden shelters. The use of steel and concrete in feedlot construction is becoming more common in larger feedlots.

Shelters are most often provided in small feedlots; they are usually three sided, open front sheds. Large feedlots, on the other hand, seldom provide sheds; however, 6' to 8' high board fencelines are used to protect cattle from prevailing winds.

In addition to pens, shelters, and windbreaks, many feedlots, especially the larger operations, provide additional facilities for convenience and handling of cattle. These include paved pens and feed alleys, concrete bunks, hospital sheds or pens, scales, squeeze chutes, and loading docks. The use of these items appears to be a matter of choice rather than necessity. Many small and large feedlots utilize some, or all, of these facilities, although the capital investment required does limit their use in small feedlots.

Feeding Systems

There are two basic feeding systems used by Alberta feedlots: the feeding of calves from weaning to heavy feeder weights of 600 to 700 pounds and the finishing of heavy feeders to slaughter weights of 950 to 1,100 pounds. The range of weights for each system represents both heifers and steers, with the former falling into the lighter weights. Under the

first system calves are weaned and fed relatively low energy rations during what may be referred to as a growing and conditioning feeding program. The animals are then either sold or remain in the same feedlot to be fed out to slaughter weights. The feedlot finishing program consists primarily of high energy concentrate rations. In Alberta these rations are predominantly barley, although some wheat may be added during the latter part of the finishing period.

The calf-to-heavy feeder system involves a dry lot and a pasture stage of feeding. Calves enter the dry lot phase during October and November and remain until April, at which time those animals weighing 600 to 700 pounds enter the feedlot finishing stage of production. The lighter yearling calves return to the range for a summer feeding period and then either return to the feedlot or remain as replacement cattle. The producer's choice of feeding systems is determined by his available resources for cattle feeding.

The feedlot finishing program is designed to produce slaughter animals weighing 900 to 1,100 pounds and grade good to choice. This program has been necessitated by the consumers' demand for highly finished smaller cuts of beef. The entire feeding period is carried out under dry lot conditions and requires approximately 40 days per 100 pounds of gain. In other words, a 700 pound animal fed to 1,100 pounds would require about 160 days in the feedlot depending on the type of cattle and the rations used for finishing.

Alberta cattle feeders have a limited choice of feedstuffs available for cattle feeding. The concentrate portion of the first feedlot

system consists of barley and oats; whereas the second feeding system relies primarily on barley and occasionally some wheat. The roughage portion of the total ration in each system is highly variable. Forages used include tame and wild grasses, crop residues, as well as cereal and legume crop silages. The latter is becoming more prevalent as a roughage source for cattle feeding because of its nutritional value and adaptability to mechanized feeding facilities.

Cattle Industry Input Availability

Beef cattle production is dependent upon an abundant supply of feed grains and forage. The cow-calf enterprise is almost completely dependent upon abundant supplies of relatively inexpensive forage for summer and winter feeding. Alberta has an estimated 19.3 million acres of land used entirely for pasture (Table 6), and approximately 6.3 million acres of crop residue used for grazing. This land provides sufficient pasture for approximately 1.11 million cow-calf units. Therefore, the available range and grazing lands of the province can be considered as being stocked to capacity in 1966, when the Dominion Bureau of Statistics reported 1.11 million cows in Alberta [6]. However, the province does have the potential to carry 1.75 million beef cows [11].

Alberta's feed grain situation will support a substantial increase in cattle feeding. In 1969 a total of 5.3 million acres of wheat 5.1 million acres of barley, and 2.1 million acres of oats were seeded by Alberta grain farmers [3]. The estimated yields from these acreages were 136.8, 196.4, and 87.9 million bushels, respectively, for the three crops reported. Assuming an average feedlot feed conversion of 7:1 and an

Table 6

PASTURE ACREAGE BY TYPE - ALBERTA 1964

Type of Pasture	Total Acres (000's)	Distribution Including Crop Residue	Distribution Excluding Crop Residue
Unimproved Native	16,345.0	67.3	84.5
Improved Native	1,330.0	5.2	6.9
Tame	1,540.0	6.0	8.0
Irrigated Tame	94.2	0.3	0.5
Total Grassland Pasture	19,309.2		100.0
Crop Residue	6,334.0	24.7	
Total Including Crop Residue	25,643.2	100.0	

Source: H.C. Love and M.L. McMillan, Alberta Pasture Resources and Estimated Potential Beef Production from Improvement of Privately Owned Land, Agricultural Economics Research Bulletin No. 6 (Edmonton: University of Alberta, 1968), p. 5.

average gain of 350 pounds per animal fed, Alberta's 1969 recorded slaughter of 963,587 animals would have utilized approximately 48.2 million bushels of barley, or about 25 percent of the province's estimated 1969 production. Considering the present surplus grain situation and the requirements of other livestock and poultry, there is little reason to expect feed grains to limit the feeding of cattle in Alberta.

The continued growth and development of the beef industry of Alberta will be determined by the supply of feeder cattle in the province and the industry's ability to compete with other regions for processed beef markets. Alberta's rangelands are presently stocked to capacity. Any increase in feeder cattle production will necessitate that new lands be allocated to forage production or the carrying capacity of existing range be increased. Improvement of native range areas through reseeding and improved management techniques would provide an additional 1.266 million animal unit months of forage for beef production [15]. Reallocation of marginal grain lands to forage production holds a large grazing potential. This adjustment is presently being considered by grain producers in the province and could contribute significantly to reducing the existing grain surplus.

Depressed feed grain prices have given Alberta feedlot operators a competitive advantage in cattle feeding. Much of this advantage will be lost when prices return to normal levels. Therefore, the beef industry of the province must develop new techniques in the breeding, feeding, management, and marketing of cattle if they are to remain competitive with other producing regions. A discussion of some of these factors will be presented in Chapter II.

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CHAPTER II

INDUSTRY PROBLEM ANALYSIS

Alberta Agriculture

The past two decades have been a period of rapid economic growth in agriculture. This growth has come at a cost to farm people in the form of reduced purchasing power. Technological advances coupled with a decreasing farm population and increasing farm size have resulted in a substitution of capital for labor. From 1961 to 1966 farm numbers decreased by 5.2 percent, while farm population decreased 2.2 percent from 287,814 to 281,583 [7]. During this same period the average size and value of farms increased to 705 acres with a capital investment of $41,242.

Alberta farm output increased substantially over the 1961 to 1966 period. Based on 1949=100, the farm output index stood at 144.9 in 1961 and increased to 215.3 in 1966. Although the trend in agricultural prices in general has been downward, the rate of increase in production has more than compensated for the decrease resulting in an upward trend in total farm cash receipts. When the increased farm receipts are discounted for the higher investment cost and inflation, farm purchasing power has shown a downward trend. The agricultural producer has been caught in a "cost-price squeeze."

As a province, Alberta has 7 percent of Canada's people and is one of the three major producers of livestock and cereal grains in Canada. These agricultural products are produced in a surplus magnitude and must

be exported to other provinces, the United States, or sold to other nations on the world market. The development of new markets for wheat and feed grains has not kept pace with the growth in production of these products and a serious suplus situation has developed. Canada has been relatively inactive in the promotion and sale of agricultural products in the world markets. Its share of the feed grain trade has dwindled to less than 3 percent. Canada has defaulted to a "residual supplier" position in both wheat and feed grains. The problems facing the Alberta farmer are the result of both production and marketing inefficiencies. The former are concerned with resource allocation within agriculture, production practices, and cost-output relationships. Marketing efficiency is primarily concerned with the value-adding processes that take place between the product on the farm and the final purchase of the product by the consumer. It also involves the grades and standards of products produced, prices, and promotion of products.

Production efficiency implies the maximization of output-input ratio (or the minimization of the input-output ratio). From an agricultural producer's viewpoint, the former has been emphasized. As the purchasing power of producers declined, their reaction was to increase the output of agricultural commodities per unit of inputs used in the process. This adjustment has taken the form of capital intensive techniques to reduce the labor requirement per unit of output, fertilizer to increase crop production per land unit, and feed supplements to increase the pounds of livestock produced per unit of the factors of production used. Many such examples could be cited, and those indicated clearly demonstrate the principle involved.

When more than one product can be produced, the efficiency criterion holds within each production process as well as in the allocation of resources between or among processes. Resources must be distributed in such a way that the marginal value products of each enterprise are equal. Farmers tend to allocate their resources for maximum profits.

> "If prices can be taken to reflect consumer choice, the marginal conditions outlined for maximizing the physical product of the farm, with resources limited in quantity, also become the marginal conditions necessary for attaining maximum efficiency from the standpoint of society" [3].

In other words, society has a right to expect efficiency. These conditions are met provided resources are free to move within agriculture. These same conditions result in producer maximization of physical product.

The nature of the agricultural process makes any equilibrium condition difficult to achieve. Output is extremely variable as a result of seasonal conditions, and producers are continually adjusting to new technology or market situations. When price becomes an exogenous variable, the adjustment process may not perform, and serious surpluses or shortages may develop. Alberta grain producers are being encouraged to divert part of their wheat acreage to summer fallow, to forage, or livestock production. Grain prices have not been allowed to adjust downward except for those grains entering the domestic livestock feed market. This situation is not necessarily in line with the efficiency criteria outlined above. The adjustment from wheat production to other grains or livestock production should involve only the marginal or inefficient wheat producers. In this way the efficient grain producer would remain in production and possibly be able to decrease his cost per unit of output through additional inputs, or through expansion to take advantage of economies of size relationships

in wheat production.

Beef Industry

Alberta's livestock and poultry industries operate in an essentially North American market. The United States population and production of meats are approximately ten times greater than those of Canada and, as a result, strongly influence Canadian production. Livestock and poultry move relatively freely across the border between the two countries according to the price differentials in the markets. Once the price spread becomes large enough to compensate for transportation, tariff, and currency exchange costs, animals move from the lower to the higher priced market.

The United States holds a large market potential for Alberta livestock provided producers are able to compete with their American counterparts. The present depressed feed grain market in Alberta gives producers a considerable production cost advantage in the North American market. However, the adjustment that is expected to take place in the grain producing sector of the agricultural economy could offset much of the present advantage.

Beef production is an important segment of the agricultural economy of Alberta. It accounted for 31.1 percent of the province's total farm income in 1968 [2] and has shown a continuous increase over the past ten years. Between 1961 and 1966 the number of cattle on Alberta farms increased by 550,000 head [7]. The province produces 37.5 percent of the nation's beef, with 1,119,000 beef cows reported on farms in 1966 [1].

The outlook for beef production is for a continued growth to parallel the needs of an increased population.

The rapidly increasing demand for beef that is expected to take place during the 1970's may not only create problems of increasing beef cattle numbers, but will place an ever increasing emphasis on production and marketing efficiency. The price system may assure sufficient resource allocation to beef production, but the cost of these resources could place the beef producer at a competitive disadvantage with hog and poultry producers. The cow-calf operation requires an abundance of relatively inexpensive forage, placing it in competition with other land based enterprises. Based on 1961 requirements, Love and McMillan [5] have estimated that by 1980 the feed production equivalent of 15.8 million acres of improved pasture will be required by the beef industry in Canada. With improved range management techniques this requirement could be reduced to 11 million acres of improved pasture. The Federal Task Force on Agriculture suggests that 10 million acres of wheat will need to be taken out of production by 1980 [6]. A portion of this excess wheat acreage may be allocated to beef production.

The estimated 1980 land requirement of the beef industry could place considerable pressure on land prices and would be reflected in higher beef production costs. To limit the extent of these cost increases, production efficiency must increase. The need for improving range carrying capacities through reseeding and fertilization was emphasized by Love and McMillan [5]. Further intensification can be realized through increased calving percentages and heavier calf weaning weights. Other methods of increasing

the efficiency of beef production must center around the improvement of rates of gain and feed conversions. The beef animal has the highest feed conversion of all classes of livestock used for meat, requiring approximately 7.5 pounds of feed for every pound of live beef produced. These production inefficiencies must be overcome if beef is to remain competitive with other sources of meat in the food market.

The problems of the beef industry involve the feeder cattle producer, the feedlot operator, and packing plants in a general scheme of production and marketing. The present lack of production scheduling and market information results in inefficiencies throughout the system. Beef calves are born in the spring and enter the slaughter cattle market the following spring or summer resulting in extreme fluctuations in the supply of both feeder animals and slaughter cattle. Such a problem could be overcome through a system of early spring and late summer calving followed by a method of feeding that would release cattle for the slaughter market in more or less uniform numbers throughout the year. In this way much of the risk involved in beef production could be eliminated.

The present system of beef cattle marketing does not inform producers of the merits of the product they offer for sale. This lack of information hinders producers in making quality improvements in the beef animal. A grading system that correlates consumer demand with slaughter cattle must be adopted. Similarly a grading system for feeder cattle would assist the feedlot operator in purchasing animals that would provide for efficient feedlot gains and meet the slaughter cattle market requirements.

Feedlot Operators

The Alberta beef feedlot operator has been caught in a market price squeeze. He purchases feeder cattle on a Canadian market while selling his slaughter cattle on a North American market. Pressure has been placed on Alberta feeder cattle supplies by out-of-province cattle feeders and by grain farmers who have started feeding beef cattle as a means of marketing their surplus grains. The increased demand has forced feeder cattle prices upward at a much greater rate than has been experienced in the slaughter cattle market. Prices paid for feeder cattle have been in response to the grain market rather than a reflection of the demand for beef. Consequently, feeding margins have dropped substantially.

The feedlot operator must become more competitive if he is to make a satisfactory return on his investment. He is unable to influence the price of his output, the price of feed grains, or the price of feeder cattle; therefore, any improvements in the rate of return must come through increased production efficiency as related to the nonfeed costs of feedlot operation. Approximately 85 percent of the total cost of feeding cattle results from interest on operating capital and feed inputs. The remaining 15 percent may be grouped into the category of nonfeed costs.

Reduced profit margins leave the producer two alternatives for maintaining his return on investment: (1) He may increase the level of efficiency with his present output, thus increasing profits per unit produced, or (2) he may expand his total output and at the same time maintain or increase the profit per unit of output. The latter alternative involves both the size of plant and the rate of utilization. It is then of extreme

importance to the feedlot operator to decide which of the above alternatives will increase his profits the most with his available resources. To make this choice, he must know the possible results to expect from the alternatives available to him.

In this study these alternatives were analyzed in such a way that feedlot operators could (1) evaluate their present feedlot performance by comparison to industry averages and norms, and (2) determine the best alternative available to increase the rate of return in their feedlot operation. The feedlot operators' decisions regarding operational efficiency are limited to those areas of the productive process that contribute to the nonfeed costs of feedlot operation. These decisions must be made in a general agricultural framework with specific emphasis on the beef industry.

Many of the problem areas discussed in relation to the beef industry and agriculture in general do affect the feedlot operator but are not within his control. A convenient way to visualize these problem relationships is to utilize set theory. This mathematical concept has been summarized by Huang [4]. The general problem area of agriculture forms a set. Within this set is a subset defining those problems associated with the beef industry of which a smaller subset represents the problems of the feedlot operator.

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CHAPTER III

OBJECTIVES AND RESEARCH TECHNIQUE

Objectives

The objectives of the present study were (1) to determine the internal physical economies of size associated with beef feedlot capacity in the province of Alberta, (2) to derive a long-run average cost curve to represent total nonfeed costs per head of feedlot capacity as a function of feedlot size, and (3) to develop normative long-run average cost curves to show degrees of cost efficiency within feedlot size classifications. These objectives were set out as a means of guiding the analysis of production efficiency in Alberta beef feedlots.

Hypotheses

The framework of this study suggests two hypotheses to be tested. The first hypothesis is that economies of size do exist in the nonfeed production costs of feedlot operations and that these economies exist over the entire range of feedlot capacities present in Alberta. The second hypothesis is that the economies experienced by larger feedlots can be attributed to greater efficiency in the use of labor and equipment. The analyses used in this study were directed toward verification or rejection of these hypotheses. These hypotheses could be restated in null form; in these forms the acceptance-rejection criterion would be reversed. In any case, the second hypothesis becomes relevant only if the first hypothesis test results indicate economies of size.

Data Sources

The data used in this study were obtained primarily from a questionnaire survey conducted by the Department of Agricultural Economics and Rural Sociology, the University of Alberta, and directed by Dr. H. C. Love of that department. The information was obtained in 1967. A copy of the questionnaire used in this survey is presented in Appendix G. This survey was designed to secure a profile of information on beef feedlot operations in the province. The questionnaires completed and returned by feedlot operators provided a reasonable cross section of the range of feedlots operating within the province. Other sources of data included: Dominion Bureau of Statistics publications, Canada Department of Agriculture livestock marketing reports, and Alberta Department of Agriculture Statistics for Agriculture.

Analytical Procedure

To facilitate the analysis, the annual fixed costs, including interest and depreciation on the capital investment, and the variable nonfeed costs for each sample feedlot were calculated on a basis of feedlot capacity. No adjustment was needed for fixed costs because they remain constant regardless of the number of cattle fed. Variable costs were adjusted to conform with a 1.0 feedlot turnover rate. This procedure was necessary because these costs remain constant on a per head fed basis. The feedlot turnover rate is the ratio of the total number of cattle fed per year to the feedlot capacity.

The technique of regression analysis was used to estimate total

investment and total nonfeed cost functions with respect to feedlot capacity. Several functions were used including both logarithmic and linear forms, and the results were compared. The linear form provided the best fit, indicating that economies of size relationships were present over the range of feedlot sizes in the sample data.

The sample was stratified according to the feedlot capacity size criterion as reported by the operator. The number of observations in each stratum declined as the size of feedlots increased. It was assumed that fewer feedlots in the larger size classifications would not distort the results of the analysis because of the greater uniformity and precision of the records of these feedlots. The actual division between size groups was based largely on judgement and on obvious breaks in the range of sample data.

The composite firm budgeting approach was used to develop representative firms for each sample stratum. Total nonfeed costs were obtained as the sum of fixed costs and adjusted variable costs, and stratum size was computed as the average of feedlot capacities in the respective stratum. Short-run average cost curves were then developed as a series of points corresponding to different feedlot turnover rates. The long-run average cost curves representing economies of size for different rates of feedlot utilization were formed as the locus of equal turnover rates across the short-run average cost curves. The 3.0 turnover rate, long-run average cost curve indicated the maximum efficiency level of operation attainable and thus provided a basis for comparing feedlot sizes. This rate of turnover would require the feedlot to

operate at capacity throughout the year.

The final stage of the analysis involved the development of normative beef feedlot cost functions. The stratified sample data for the five smaller size classifications of feedlots were truncated to form quartiles within each stratum. Long-run average cost curves for various combinations of quartiles were developed for the 3.0 turnover rate of feedlot utilization.

CHAPTER IV

THEORETICAL FRAMEWORK FOR ECONOMIC ANALYSIS

Production Analysis

Production analysis relies heavily on the objectives of the firm and the competitive framework within which the firm operates. In economic theory the firm is most often assumed to have a profit maximization objective; however, other alternatives have been suggested as being more representative of the firm. These objectives include a profit constrained sales maximization [3] the behavior approach [16], utility maximization [1], and the satisfaction objective [15]. Each of these propositions has some merit. The profit maximization firm objective remains the more commonly accepted and will be used as a satisfactory summary objective in the analysis to follow.

The level of output at which the firm will maximize profits is conditioned by the competitive framework of the factor and product markets in which the firm purchases its input, and sells its output. On the factor side this framework may range from perfect competition to monopsony, while on the product side the market structures vary from perfect competition to monopoly. Under conditions of perfect competition the firm's output decisions do not affect prices in either the factor or product markets; however, all other market structures do have a quantity-price relationship that affects factor costs or product prices. These competitive structures can be derived mathematically from the firm's long-run profit maximization objective function $\Pi = TR - TC$, where total

revenue (TR) is determined by the price of the output (P_y) and the quantity of output sold (Y). Similarly total cost (TC) is the price of the input (R_x) times the quantity of input used in the process (X). Therefore, the objective function may be restated as

$$\Pi = P_y \cdot Y - R_x \cdot X. \tag{1}$$

The profit maximization condition where marginal revenue (MR) is equal to marginal cost (MC) can then be determined by differentiation:

$$MR = \frac{d(TR)}{dY} = P_y \cdot \frac{dY}{dY} + Y\frac{dP_y}{dY} = P_y + Y\frac{dP_y}{dY} \tag{2}$$

and

$$MC = \frac{d(TC)}{dX} = R_x\frac{dX}{dX} + X\frac{dR_x}{dX} = R_x + X\frac{dR_x}{dX} \tag{3}$$

The profit maximization level of output can be determined by equating the first derivative of the profit function to zero and applying the chain rule to the production function $Y = \phi\ (X)$ [20].

$$\frac{d\Pi}{dX} = 0 = P_y\frac{dY}{dY} \cdot \frac{dY}{dX} + Y \cdot \frac{dP_y}{dY} \cdot \frac{dY}{dX} - R_x\frac{dX}{dX} - X\frac{dR_x}{dX}$$

$$= P_y\frac{dY}{dX} + Y\frac{dP_y}{dX} - R_x - X\frac{dR_x}{dX}. \tag{4}$$

Under conditions of perfect competition in both the factor and product markets the second and fourth terms of the above equation would be null. Should the firm exhibit some monopsony power in the factor market, the fourth term would be non-zero, or if it has some monopoly power in the product market, the second term would be non-zero.

Production is the transformation of goods and services (inputs) through changes in form, space, or time, into other goods or services (outputs). The quality and quantity of output produced is determined by the amount and kind of inputs used. This factor-product (input-output)

relationship may be described mathematically by a production function $Y = \phi(X)$ where Y and X are vectors and a given state of technology is assumed. Heady [5] has shown that the production function for a single output using more than one input can be stratified according to a time variable to yield a long-run production function

$$Y = \phi\ (X_1, X_2, \ldots, X_k, X_{k+1}, \ldots, X_m) \tag{5}$$

and a short-run production function

$$Y = \phi\ (X_1, X_2, \ldots, X_k, \overline{X}_{k+1}, \ldots \overline{X}_m) \tag{6}$$

where the symbol "bar" over inputs indicates input fixity. In both the long-run and short-run situations, the state of technology is fixed. The major difference between the two situations is the number of variable inputs. Plant size is most commonly fixed in the short run.

Considering the production function $Y = \phi\ (X_1, X_2)$ for a single-output-two-variable-input case, productivity relationships can be derived by treating the quantity of one of the variable inputs as a parameter and expressing output as a function of the other variable input [7]. The average product (AP) is the ratio of the total product to the quantity of variable input used, and the marginal product (MP) is the rate of change in total product resulting from variations in the quantity of the input used. These relationships are shown by the productivity curves of Figure 5. Since the production function is continuous, several combinations of inputs may yield the same level of output. This phenomenon can be demonstrated by isoquants (Figure 6). As the level of output increases, the isoquants representing infinite combinations of inputs become further removed from the origin. The minimum cost input combination is established

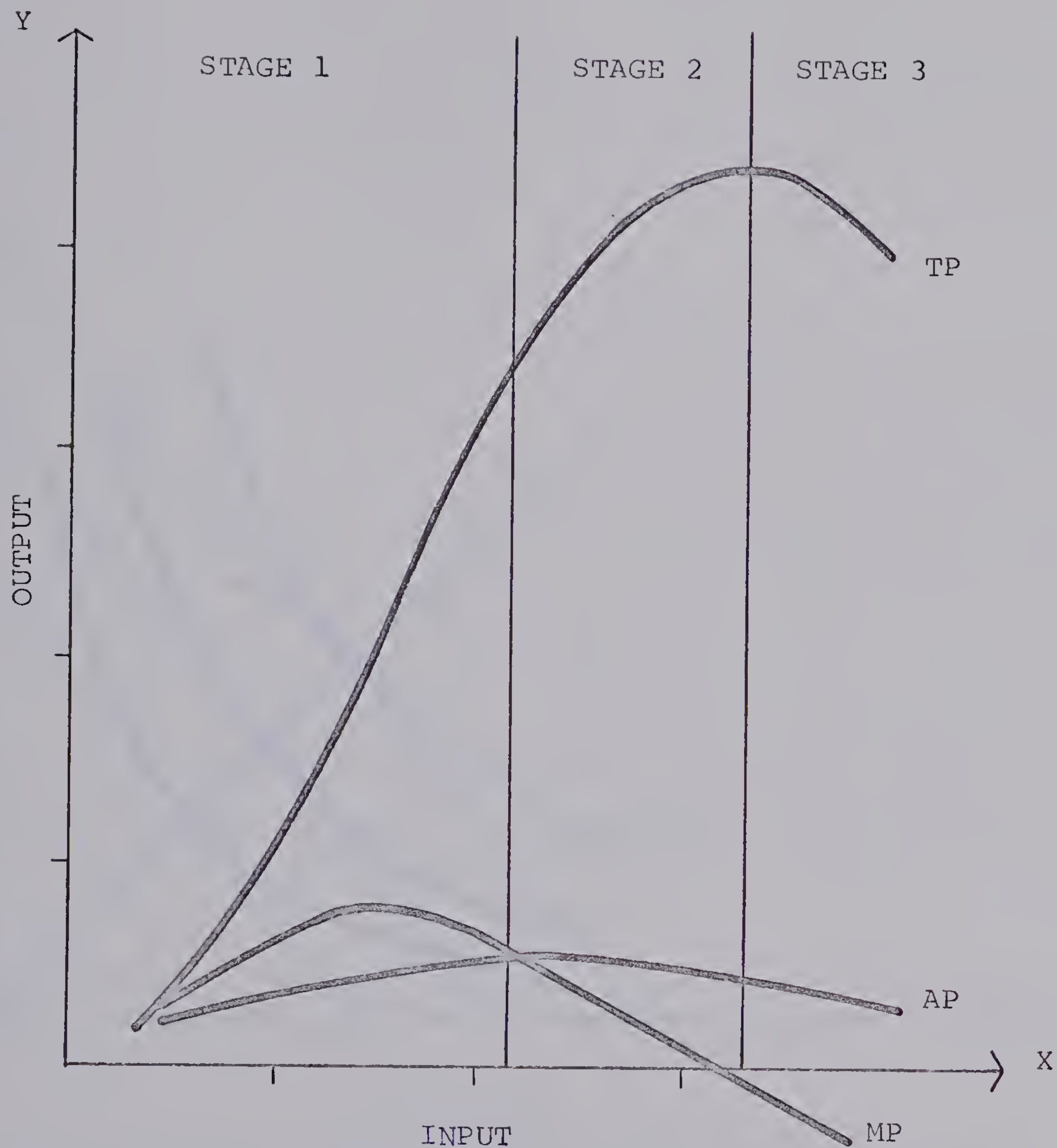

Figure 5

PRODUCTION FUNCTION WITH CORRESPONDING PRODUCTIVITY CURVES

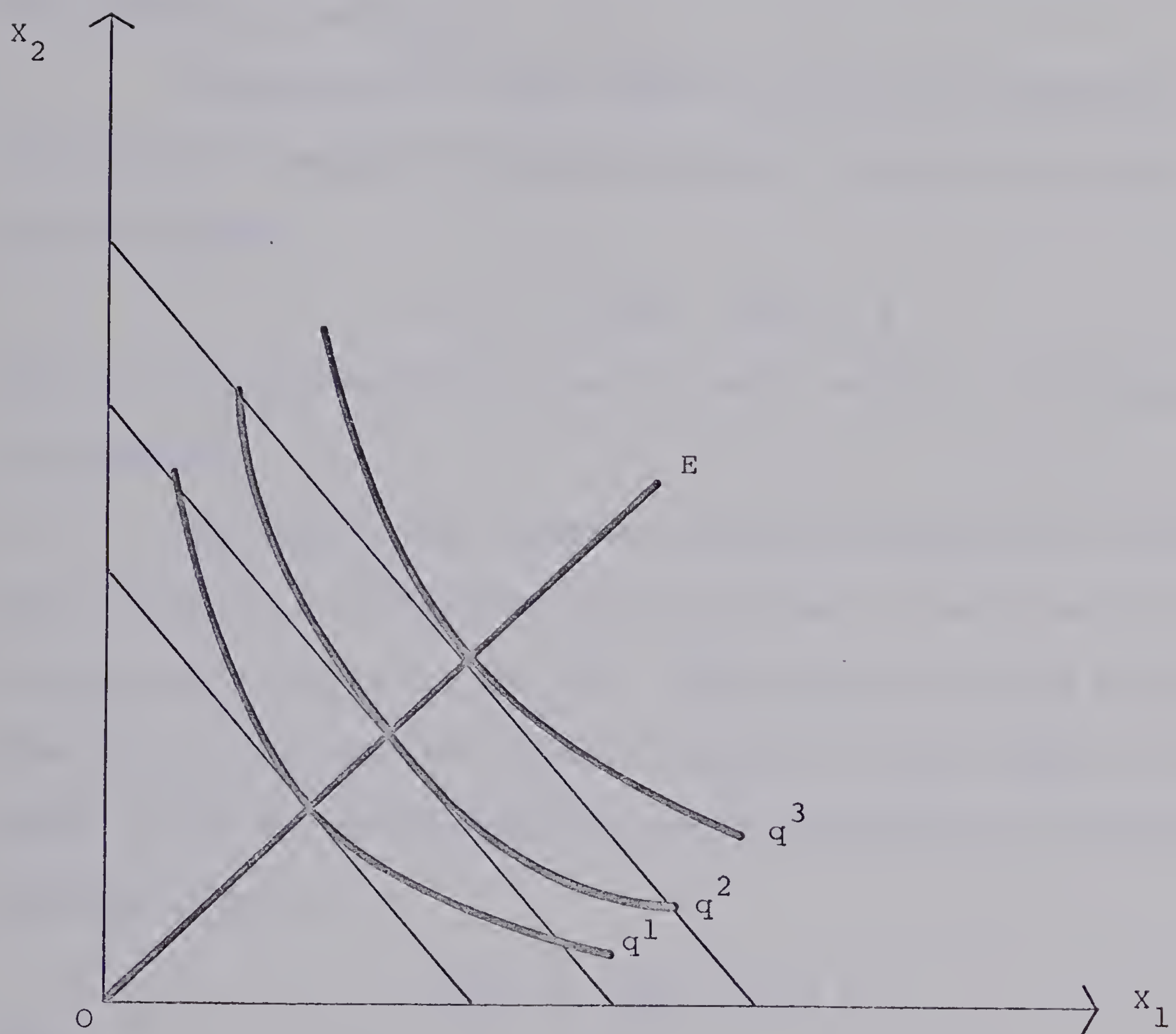

Figure 6

ISOQUANTS FOR THREE LEVELS OF OUTPUT SHOWING ISOCOST LINES AND EXPANSION PATH

at the point where the isoquant is tangent to the lowest possible isocost line [4]. The latter shows the various combinations of inputs that may be purchased for a stipulated amount of expenditure. The optimality condition can be shown mathematically as the maximization of the output-input ratio (the efficiency condition).

Considering the firm's objective of profit maximization, when operating in a perfectly competitive market, the short-run profit equation becomes

$$\Pi = P_y \cdot Y - R_1X_1 - R_2X_2 - F \tag{7}$$

where R_i is the price of the input X_i, and F refers to the fixed costs of production.

The first order condition for profit maximization requires that the value of the marginal physical product of each input (X_1 and X_2) be equal to its price (P_1 and P_2). This condition is found by differentiation of the firm's short-run profit function (7) with respect to the inputs X_1 and X_2, and equating the partial derivatives of the profit function to zero:

$$\frac{\partial \Pi}{\partial X_1} = P_y \cdot \frac{\partial Y}{\partial X_1} - R_1 = 0$$

and

$$\frac{\partial \Pi}{\partial X_2} = P_y \cdot \frac{\partial Y}{\partial X_2} - R_2 = 0 \tag{8}$$

Rearranging gives:

$$P_y \cdot \frac{\partial Y}{\partial X_1} = R_1 \quad \text{and} \quad P_y \frac{\partial Y}{\partial X_2} = R_2. \tag{9}$$

Equation (9) indicates the first order condition of profit maximization—the marginal value product is equal to the marginal cost. Manipulation of this equation gives:

$$\frac{\partial Y/\partial X_1}{\partial Y/\partial X_2} = \frac{R_1}{R_2} \tag{10}$$

The optimum combination of the factors (X_1 and X_2) can be found by taking the total differential of the isoquant $Y° = \phi(X_1X_2)$ and equating the result to zero:

$$dY° = 0 = \frac{\partial Y}{\partial X_1}\, dX_1 + \frac{\partial Y}{\partial X_2}\, dX_2 \tag{11}$$

Rearranging gives the optimum factor combination:

$$\frac{\partial Y/\partial X_1}{\partial Y/\partial X_2} = - \frac{dX_2}{dX_1} \tag{12}$$

The marginal rate of substitution is equal to the slope of the isoquant. Relating the optimum factor combination condition to the profit maximization condition results in a point on the expansion path:

$$\frac{R_1}{R_2} = - \frac{dX_2}{dX_1} \tag{13}$$

which is the optimization requirement that the slope of the isoquant is equal to the slope of the factor price line, or the marginal rate of substitution is equal to the price ratio.

The second order condition requires that the second derivative of the profit function be less than zero. This condition may be utilized to show that the rate of change of the slope of the tangent to an isoquant must be positive ($d^2X_2/dX_1{}^2>0$) at the point of tangency with an isocost line [8]. In other words, the isoquants must be convex from below as shown in figure 6.

Cost Analysis

Cost analysis is a reflection of production analysis. The total

cost function can be derived from the production function showing the relationship between varying levels of factor cost and the corresponding output of product. These relationships can be expressed as a short-run and a long-run system of equations. The short-run system would be:

$$Y = \phi\ (X_1, X_2, \ldots X_k, \overline{X}_{k+1}, \ldots, \overline{X}_m) \tag{14}$$

$$TC = R^1X + F \tag{15}$$

$$0 = g(X) \tag{16}$$

where equation (14) is the familiar short-run production function. The total cost function (15) is derived from the production function by assigning prices to the variable and fixed factors used to produce the output Y. On the right hand side of this equation the first term (R^1X) represents the variable cost of production, while the second term is the fixed cost. Total cost is the sum of total variable costs and total fixed cost (i.e. TC = TVC + TFC). Equation (16) is the implied short-run expansion path function of equation (11); that is, expansion is not possible.

The corresponding long-run system of equations for cost analysis would be:

$$Y = \phi\ (X_1, X_2, \ldots, X_k, X_{k+1}, \ldots, X_m) \tag{17}$$

$$TC = R^1X + Y(E) \tag{18}$$

$$0 = g\ (X, E) \tag{19}$$

where (E) represents an expansion path variable. In the short-run analysis plant size is held constant and the optimum factor combination is a point on the expansion path. In the long-run situation all factors, including plant size, are variable, and the optimum becomes the expansion path. The

symbol (E) in equation (18) is used to designate the corresponding range of plant capacity and reflects cost differences related purely to size.

Average and marginal cost functions can be determined directly from the total cost functions of (15) and (18) above. Average total, variable, and fixed costs are formed by dividing the right hand side of equations (15) and (18), the first term, and the second term, respectively, by the total output. Marginal cost for the short-run situation is the first derivative of the total cost function. Because of the expansion path variable in the long-run total cost function, the long-run marginal cost cannot be determined directly. However, by first determining the long-run average cost curve (LRAC) as the envelope curve tangent to a series of short-run average cost curves (SRAC) representing various plant sizes, the LRMC may be determined as the locus of points on the SRMC curves corresponding to the tangency points of the SRAC curves and the LRAC curve [19].

The relationships between the production function and the short-run cost functions are shown in Figure 7. It will be noted that the profit maximization level of output is at the point where the $MPP_x = 0$, and at this point the MC = ATC. This profit maximization point can be derived as follows:

$$\Pi = PY - C(Y)$$

$$\frac{d\Pi}{dY} = P - C'(Y) = 0 \qquad \text{(i.e. MC = MR)}$$

$$\frac{d^2\Pi}{dY^2} = - C''(Y) < 0$$

Therefore, C''(Y) is greater than zero so MC is an increasing function at the profit maximization point where MR = MC.

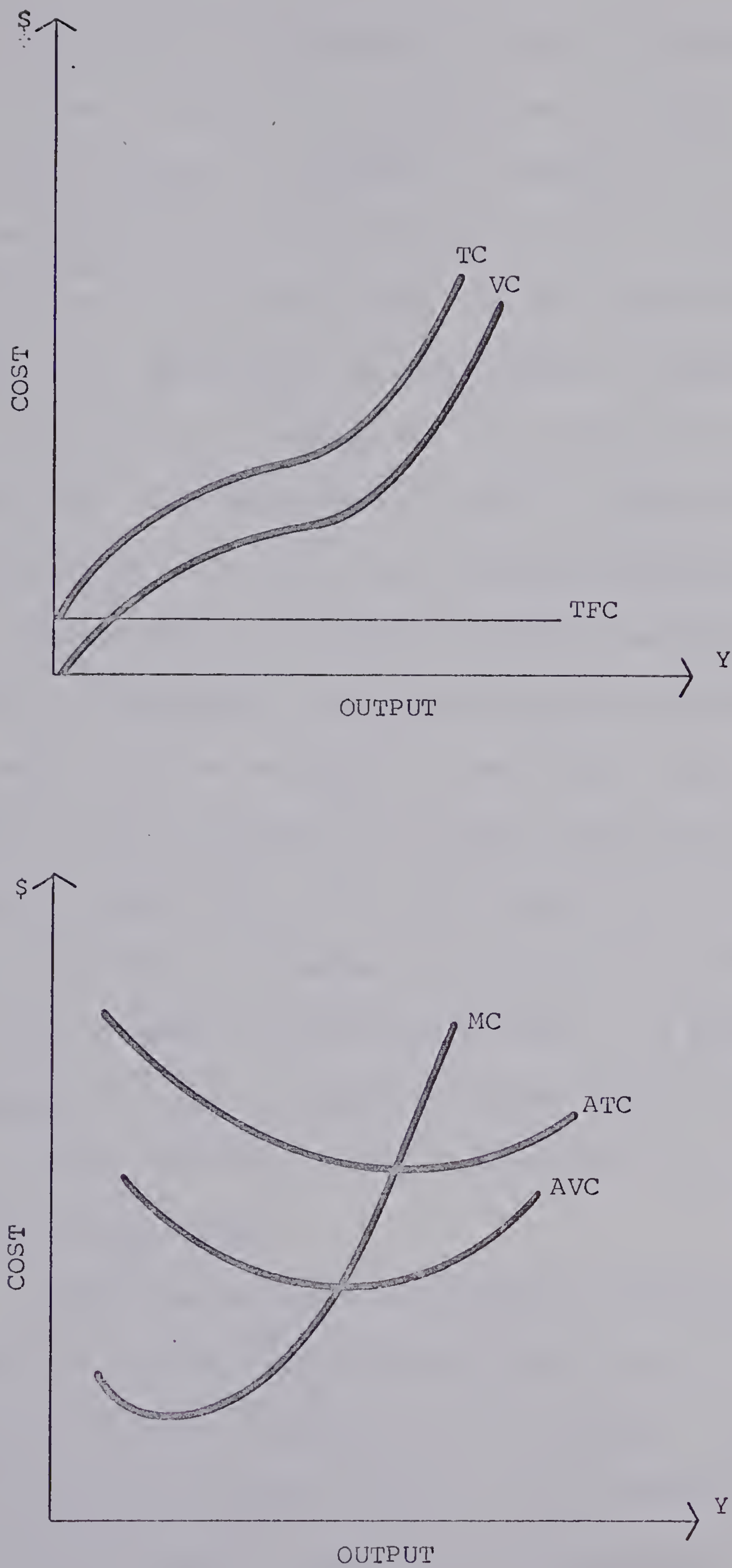

Figure 7

RELATIONSIP OF TOTAL, AVERAGE, AND MARGINAL COSTS

Relation to Study Objectives

The analysis of economies of size relationships rests heavily upon the economic concepts of the short-run and long-run cost analyses. The short-run situation, as defined by economists, is a period of time of insufficient duration to vary all of the factors of production. Plant size is thus held as a fixed factor. As such, short-run economies result from fuller plant utilization or efficiencies in buying or selling. The long-run situation is a planning horizon in which all of the factors become variable. The entrepreneur is able to adjust the rate of plant utilization as well as plant size to increase production efficiency.

Conventional cost theory represents the short-run and long-run situations by conventional cost curves described earlier. Short-run average cost curves are developed for each plant size to show how the per unit cost of output decreases as the plant becomes more fully utilized. The long-run average cost curve is then drawn as the envelope curve, tangent to the short-run average cost curves to show the relationship of per unit cost of output and the size of plant. In general, the average cost decreases as output increases until the plant is operating at capacity; further reduction in the average cost can be realized by increasing the plant size.

As the firm strives to increase its efficiency by moving down the average cost curve, utilizing the present state of technology, innovations may shift the production function upward. Because the short-run cost curves are inversely related to the production function, the average cost curve shifts downward thus preventing the firm from reaching

the minimum obtainable average cost of production. This relationship of the production and cost functions is shown in Figure 8, with the dotted curves indicating the shift resulting from an innovation.

The cost curves of Figure 7 have been drawn in the familiar U-shape as suggested by conventional cost theory. However, recent theoretical developments, as well as empirical evidence, do not support the diseconomies resulting in the increasing portion of the average cost curve to the right of the minimum average cost point. A linear non-homogeneous total cost function, which when differentiated results in a constant marginal cost function, has been suggested [2], [13]. The average cost per unit of product would decline throughout its range, becoming asymptotic to the marginal cost curve (Figure 9).

The shape of the long-run average cost curve to the left of the minimum average cost depends on the production function. Should this function be homogeneous of degree one the long-run curve becomes a horizontal straight line, provided input prices remain constant. A decreasing average cost curve corresponds to a homogeneous production function of degree greater than one, and would have an elasticity of production greater than one indicating economies of size (i.e. $E_p = \frac{dY}{dX} \cdot \frac{X}{Y} > 1$, or $MPP_x > APP_x$) [22].

In general, the long-run average cost curve can be expected to decrease over a considerable range as the size of plant is increased. There are several advantages favoring the large firm that suggest per unit costs may not rise as the level of output is increased beyond the minimum average cost point. "Per unit costs rise when output becomes too intensified—too much output per unit of time (say, per hour) is 'squeezed'

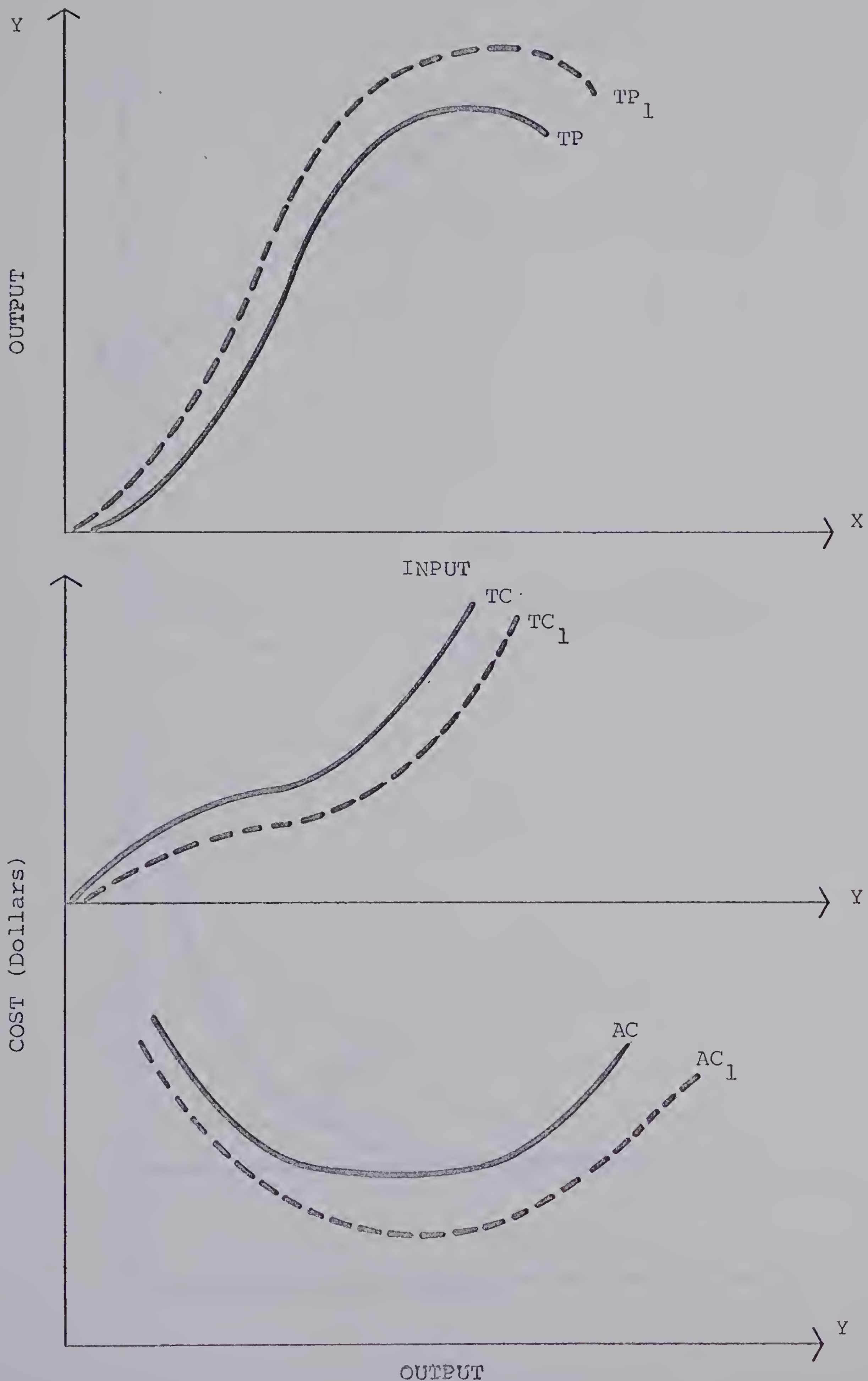

Figure 8

THE EFFECT OF AN INNOVATION OF THE PRODUCTION AND COST FUNCTIONS

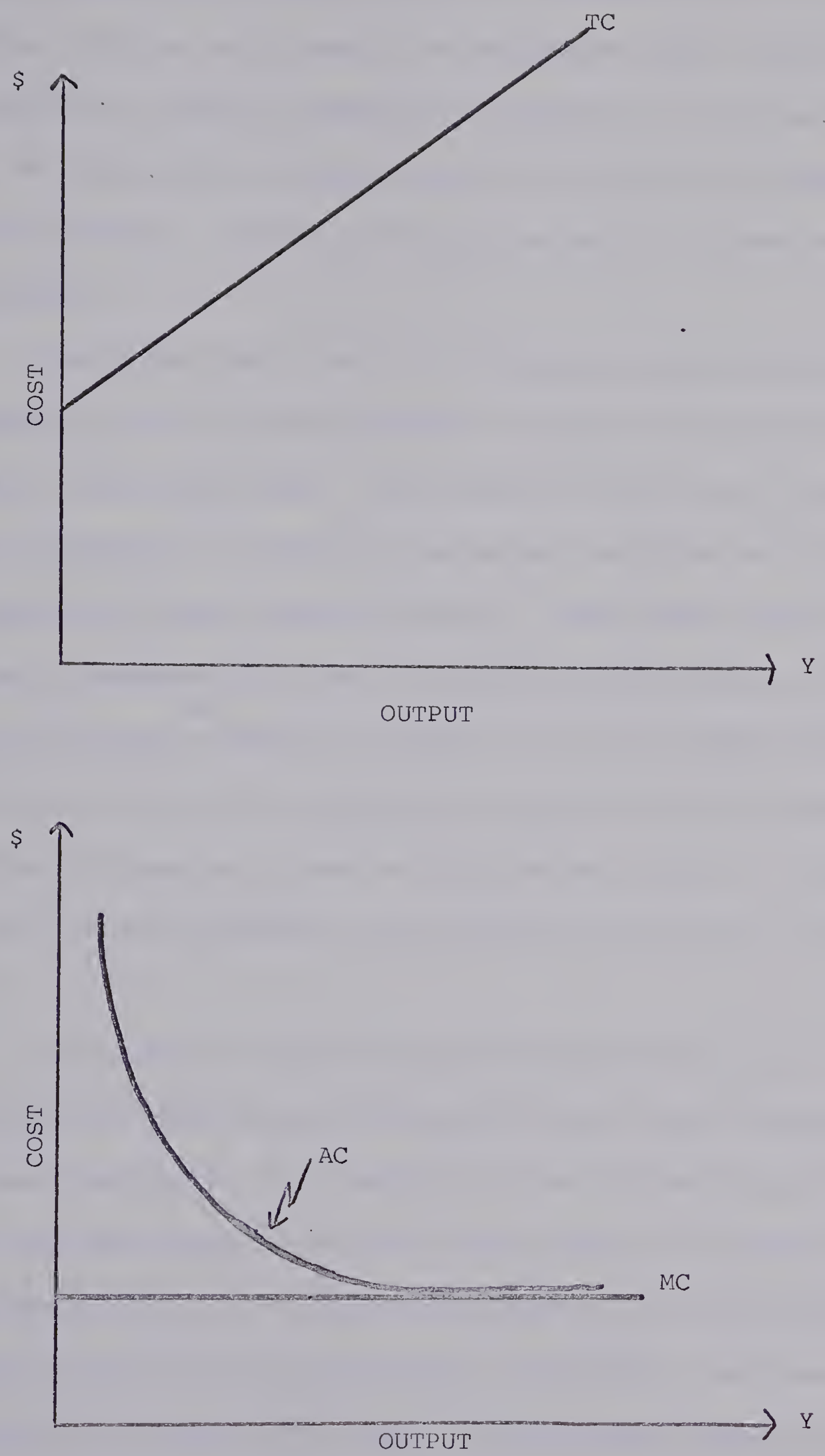

Figure 9

LINEAR TOTAL COST FUNCTION AND RESULTING AVERAGE AND MARGINAL COST FUNCTIONS

through a given plant facilities" [20]. Extension of the hours of operation allow per unit costs to be maintained while output is increased [9]. Should the plant be operating at capacity on a 24 hour per day basis, the larger firm may duplicate its facilities to prevent per unit costs from rising. This type of output expansion is known as plant segmentation.

The large firm is able to utilize the most efficient techniques of production. All of the techniques available to the small firm are available to the large firm. The converse is not true. Many of the capital intensive, cost reducing techniques available to the larger firm are prohibitive to the smaller producer. Large-scale production allows the firm to harmonize its plant to minimize idling losses. By adapting the most efficient technique of production at each stage level, the total plant output can be maximized at the least cost per unit. Plant specialization requires access to large-volume markets. Specialization and size of plant, therefore, are limited by the extent of the market [18].

Economies of size in large-scale production tend to "centralize" plant location, while lower distribution costs tend to "decentralize" plant locations [21]. It is doubtful if the minimum long-run average cost is ever reached because of the offsetting effect of economies of size and transportation costs. The firm must minimize its total combined costs of assembly, processing, and distribution. Therefore, the shape of the long-run average cost curve to the right of the minimum average cost point generally applies only in theory.

Several techniques of analyzing economies of size relationships have been developed. These include the survivorship technique, direct analysis of firm records, composite firm budgeting, and the economic-engineering or synthetic firm approach [17]. No single technique is best for all studies. The availability of data, costs, and purpose of the study dictate the most suitable methods of analysis. In this study the objectives were centered around determining the actual economies of size that exist in Alberta feedlots, rather than determining the potential economies of size in feedlot operations. For this reason a composite firm approach similar to that used in an economies of size study for California feedlots was used [10]. This method developed the total cost functions by regression analysis and delineation of the long-run average cost curve to represent the economies of size relationships.

Previous Studies

One of the early studies of economies of size relationships in beef cattle feedlot operations is that of Hopkin [11]. He estimated the total number of cattle being fed in each geographic region of California and then made personal visits to a sample of 80 feedlots in the state. Seventy-seven feedlots were found adequate for analysis. Hopkin found little variation in the nonfeed costs among groups of feedlots with similar capacities. Costs varied significantly with differences in the ratio of numbers fed per year to feedlot capacity.

The sample feedlots were stratified, according to their capacities, into six study groups. Individual nonfeed costs were determined, and the

average investment cost for each stratum was established. This information provided the basis for establishing six composite firms represented by short-run average cost curves. The curves were delineated by varying the feeding ratio for each composite firm. Points of equal feeding ratios were then joined to form long-run average cost curves showing the relationship among average costs for each of the six models.

Short-run average cost curves consisted of two types of nonfeed costs: (1) fixed nonfeed costs and (2) variable nonfeed costs. The former were assumed to be constant regardless of the number of cattle being fed and, on a per head basis, could be reduced by increasing the feedlot turnover ratio. These costs included interest, depreciation, repairs, taxes, insurance, one half of the labor requirement, and one quarter of the administrative costs. A portion of the labor and administrative costs were considered fixed to account for supervisory labor and office expenses that would be incurred as a result of normal feedlot operation. The remaining portion of these costs were assumed to be the direct result of cattle feeding and were classified as variable nonfeed costs along with power and fuel costs. The variable nonfeed costs were held constant on a per head basis and were not subject to any economies of size relationship.

Hopkin tested the reasonableness of the cost curves developed by plotting the individual firm costs of each stratum and superimposing the respective short-run cost curves on the scatter diagram. The precision of the fit was found to increase with the size of firms due to the greater accuracy of the data supplied by the larger firms. A further check on

the cost assumptions was made by least-squares regression estimation of short-run cost curves for each size group. Comparison of these curves with those developed by variation of the feeding ratio revealed little variation.

The results of the Hopkin study showed cattle feeding to be a decreasing cost industry in California within the size range of feedlots observed. Average daily nonfeed costs per head were found to decrease from $0.1177 for the less than 1,200 head capacity feedlots to $0.0769 for those feedlots with capacities of 14,000 head or more. In terms of a 120 day feeding period, the larger feedlots could be expected to make an additional $4.896 per animal fed compared to their smaller counterpart, provided all other costs remained constant.

King [14] used the economic-engineering approach to evaluate economies of size in large commercial feedlots in California. This technique is most useful as a planning tool when an expansion of existing facilities or a new enterprise is to be established. It does not consider present operations, average, or typical situations, but is designed to estimate the potential of various sizes of plants. Cost data are estimated for each plant situation and then analyzed according to the information desired.

King's study also revealed a decreasing cost feedlot industry in California. The average nonfeed cost per head per day was found to decrease from $0.0719 to $0.0557 as the feedlot capacity increased from 3,760 head to 22,560 head. When the feedlots were operated at less than capacity levels, the nonfeed costs per head increased substantially,

indicating the importance of a high feedlot turnover rate. For example, using a 60 percent of capacity basis for all feedlots, the nonfeed costs per head per day increased to $0.0933 and $0.0679, respectively, for the 3,760 head capacity and 22,560 head capacity feedlots.

The economic-engineering technique used by King produced somewhat lower nonfeed costs per head than was indicated by the Hopkin study. The reason for this difference is the latter's dependence on average data whereas the former would correspond to the above average or normative cost situations. In other words, the economic-engineering approach can be assumed to yield potential costs, whereas the composite firm technique yields the average actual situation.

Hunter and Madden [12] used the economic-engineering technique to develop model feedlots for the South Platte Valley of Colorado. Their primary concern was to compare investment requirements and average operating costs for various sizes of feedlots using different equipment combinations. Other objectives were to determine the effect on the long-run average cost curve of operating at less than capacity levels and to compare the profit potential of various sizes of feedlots.

A considerable portion of the data used in the Hunter and Madden study was obtained from a random survey of 102 cattle feeders in the South Platte Valley. This information was conditioned by data from construction companies, machine dealers, power and fuel companies, and the Colorado tax commission. Budgets were developed for a range of feedlot situations for specific sizes of firms, and the nonfeed costs were analyzed. The results of this study indicated that the nonfeed costs

per head per day decreased from $0.097 per head to $0.083 per head as the feedlot capacity increased from 135 to 15,300 head. Fifty per-cent of this decrease was observed between the 135 head capacity feedlot and the 4,000 head capacity feedlot. The most significant results of the study were that throughout the entire range of feedlot capacities studied, the least-cost operation was achieved by the operators owning an appropriate size of feedmill and using self-unloading feedwagons to distribute feed to the cattle in the feedlot.

A more recent study of the cost economies in cattle feeding was conducted by Heady and Gibbons [6]. This study was an effort to measure and specify quantities relating to costs and profits in feedlot operations in Iowa, according the volume of feeding and degree of specialization. Four feeding methods were studied for various levels of production. These were

(1) Hand labor feeding

(2) Hand labor using a feed wagon

(3) Self unloading tractor drawn feed wagon

(4) Mechanized feeding.

Cost curves were computed for each feeding method using budgeting methods to determine labor, investment, and operating costs. The results of this study showed no important cost advantage for any method after fixed costs were spread over a volume of about 500 steers. However, when labor was charged at $2.50 per hour, the more highly mechanized feeding methods on a large scale had a considerable cost advantage. At this wage rate smaller feeders using the labor intensive methods and charging $1.00

per hour for their labor were unable to compete. Heady and Gibson concluded that the present trend in wage rates relative to capital could be expected to encourage large-scale, specialized and mechanized feeding operations. Linear programming solutions using 11 different cattle feeding systems indicated that a combination of systems, resulting in year-around marketing, produced less income variation and greater total profits through more efficient use of feedlot space and equipment. This system also allowed the averaging of prices received for cattle over the entire year and thus reduced the uncertainty associated with marketing cattle during a particular period.

The above mentioned studies revealed two general types of economies of size analysis which may be referred to as either a positive or a normative approach. The former is primarily concerned with the situation as it exists, whereas the latter attempts to establish what should be, or what could be, attained. In this study of Alberta feedlots the primary objectives were concerned with the feedlot situation as it exists, rather than with the potential economies that could be expected. The Hopkin composite firm approach discussed in this chapter is geared to this type of study and should provide useful information to feedlot operators in their decision making process.

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CHAPTER V

FEEDLOT COST FUNCTIONS

The data used in the development of the feedlot cost functions were obtained from a 1967 survey of Alberta feedlots conducted by the University of Alberta under the direction of Dr. H. C. Love. Information concerning capital investments, feedlot operating costs, number of cattle fed, and various aspects of feedlot operation was obtained from 48 feedlot operators. A considerable variation in costs, investments and practices was found throughout the range of feedlots in the sample.

In general, cattle feeding involves three distinct types of costs: (1) cattle, (2) feed, and (3) other nonfeed costs. Because of the excess demand for feeder cattle and the excess supply of feed grains available to Alberta feedlots, these costs cannot be considered as subject to any external economies. All of the cost-reducing benefits of feedlot operation must then be experienced in the internal nonfeed costs of production. The objectives of this study were centered around quantification of economies of size that may exist in the nonfeed costs of feedlot production as they pertain to the feedlot industry of Alberta.

Enumeration of Cost Data

The feedlot cost information was obtained as capital investment items and other nonfeed costs. The former was necessary to estimate the fixed costs of interest and depreciation. These items are shown in Appendix D, Tables I and II, respectively. Depreciation was calculated on

the basis of original costs using the straight line method and rates applicable for income tax calculations. Similarly fixed interest was calculated on the original investment using a 6 percent rate. This method was found to be quite acceptable because of the age distribution of feedlots in the sample and the difficulty involved in making any realistic estimates of present values when relatively few operators reported accumulated depreciation. The questionnaire did not provide information pertaining to dates of feedlot expansions or improvements. Nevertheless, the cost of these changes was included in the original cost observations. The following is a detailed description of the capital investment items reported by the feedlot operators.

(1) Land used for the feedlot site and pasture. This item was excluded from the cost analysis because its value is strongly influenced by location factors and other productive values. Its inclusion would tend to decentralize feedlot locations and cause a discrepancy in the cost-size relationships.

(2) Buildings used for living accommodations. The primary purpose for enumerating this investment category was to prevent its inclusion in the miscellaneous feedlot investment items. Its effect on the analysis would be similar to those of land values.

(3) Feedlot buildings—storage, hospital, and shelters. These items were found to be extremely varied throughout the range of feedlots studied. All feedlots reported some type of facility for the storage of grain and forage, and shelters were either natural windbreaks or fences and sheds. Hospital facilities were reported by most feedlots and were

usually barns or sheds (Appendix C).

(4) Pens and livestock feeders. A major portion of the sample feedlots reported post and plank pens with fenceline bunk feeders. Other feeding systems involved the use of self-feeders and in-pen bunk feeders. Included in this investment category were such items as paved feedlot surfaces and cement pads along feeding and watering areas (Appendix C).

(5) Water wells, pipe, and watering equipment.

(6) Trucks, tractors, and semi-trailers.

(7) Stationary feedlot equipment. These items included livestock and truck scales, feed milling equipment, squeeze chutes, conveying equipment, and other permanent feedlot facilities.

(8) Portable feedlot equipment. Included in this category of investment items were feed wagons, portable mix-mills, manure spreaders, trailers, and other movable equipment.

(9) Miscellaneous capital items. This observation included small tools, livestock handling equipment, and other minor items that were not considered in the general breakdown of investment classifications.

Capital investments in feedlot buildings, stationary equipment and miscellaneous items are a source of free capital to some of the small feedlot operators. These producers did not pay for their feedlot facilities but received them as either part of a farm purchase or inheritance. Therefore, the feedlot would have a very low fixed cost and be extremely competitive.

The above listing of capital investment items corresponds with taxation depreciation rates. This listing simplified the analysis. Total

Table 7

SUMMARY OF FIXED AND VARIABLE COSTS FOR

1.0 FEEDLOT TURNOVER RATE

Observation	Interest	Depreciation	Other	Total Fixed	1.0 Variable	Total Cost
1	9,318	13,505	71,460	94,283	32,562	126,845
2	1,897	3,109	12,733	17,739	6,287	24,026
3	1,998	3,130	6,203	11,331	7,196	18,527
4	951	1,642	3,177	5,770	3,467	9,237
5	1,390	2,874	300	4,564	1,925	6,489
6	5,760	7,100	9,056	21,916	15,151	37,067
7	5,270	9,842	12,495	27,607	11,734	39,341
8	4,472	5,423	7,154	17,049	6,681	23,730
9	786	1,570	3,074	5,430	4,808	10,238
10	380	627	793	1,800	2,056	3,856
11	2,628	3,604	20,019	26,251	9,111	35,362
12	2,910	2,875	11,255	17,040	6,608	23,648
13	2,672	4,755	5,694	13,121	2,793	15,914
14	1,767	2,633	8,215	12,615	5,678	18,293
15	1,734	2,670	3,359	7,763	2,510	10,273
16	2,561	4,359	4,947	11,867	2,219	14,086
17	2,130	3,400	8,031	13,561	4,958	18,519
18	2,789	4,274	2,445	9,508	1,307	10,815
19	642	1,174	2,395	4,211	1,635	5,846
20	1,377	1,835	4,389	7,601	2,002	9,603
21	5,213	4,513	980	10,706	1,948	12,654
22*	2,572	3,938	18,343	24,853	21,857	46,710
23	2,149	3,906	1,659	7,714	2,204	9,918
24	2,166	4,972	2,532	9,670	1,905	11,575
25	2,129	3,909	4,421	10,459	5,972	16,431
26	4,080	6,880	7,300	18,260	7,525	25,785
27	659	1,268	1,557	3,484	938	4,422
28	951	1,831	571	3,353	2,151	5,504
29	1,060	2,093	3,165	6,318	2,049	8,367
30	3,352	6,102	9,545	18,999	9,591	28,590
32*	2,706	2,050	22,259	27,015	15,872	42,887
33	2,653	3,377	4,423	10,453	2,486	12,939
34	2,550	5,450	32,795	40,795	14,114	54,909
35	444	690	2,733	3,867	1,480	5,347
36	3,990	6,425	16,792	27,207	12,915	40,122
37	2,820	3,300	10,711	16,831	8,823	25,654
39	630	1,150	7,174	8,954	2,998	11,952
40	3,181	3,578	9,835	16,594	4,402	20,996

Table 7 (continued)

Observation	Interest	Depreciation	Other	Total Fixed	1.0 Variable	Total Cost
41*	2,646	5,375	4,395	12,416	8,739	21,155
42*	4,809	7,180	14,002	25,991	7,473	33,464
43	1,846	1,946	6,582	10,374	5,325	15,699
44	2,425	4,561	3,407	10,393	4,539	14,932
45	3,669	4,695	7,465	15,829	9,414	25,243
46	585	1,045	2,005	3,635	2,135	5,770
48	1,440	1,775	1,495	4,710	900	5,610

*These observations were eventually dropped from the sample.

depreciation and fixed interest were calculated for each feedlot (Appendix D, Tables I and II) and were recorded in Table 7.

Other nonfeed costs made up the remainder of the cost information. These costs consisted of both fixed costs and variable costs. The former included taxes, insurance, repairs, telephone, and miscellaneous items. Variable costs, which were assumed to be constant on a per head fed basis, included electricity, fuel, veterinary fees, drugs and implants, and bedding costs. The fixed nonfeed cost items are those that would be experienced by the feedlot operator regardless of the number of cattle being fed. On a per head fed basis these costs decrease as the rate of feedlot utilization is increased until the feedlot is operated at capacity levels throughout the year. These costs are a source of short-run economies in feedlot operation. Other sources of short-run economies include the fixed costs of interest on the capital investment and the annual depreciation cost. Variable nonfeed costs are not subject to any short-run economies. They remain constant on a per head fed basis for any given feedlot situation. However, it is possible that these costs are a source of long-run economies. As the size of the feedlot increases, the variable nonfeed costs per animal fed could decrease through more efficient use of labor and equipment. Because a portion of the labor costs, office supplies, and accounting charges experienced by firms must be absorbed regardless of the volume of business done, the following assumptions were made in distributing these costs between the fixed and variable cost categories. Office supplies and accounting charges were assumed to be one fourth fixed and three fourths variable. Labor costs, on the other hand,

were equally divided between fixed and variable costs. This assumption was made to account for the permanent position of management and supervisory personnel. Hopkin [1] in a previous study made these same assumptions. The observed other nonfeed costs are shown in Appendix D, Tables III and IV according to their classification as fixed or variable costs. Total fixed nonfeed costs are also recorded in Table 7.

So that the feedlot observations could be placed on a comparable basis, it was necessary to adjust the variable nonfeed costs to a similar turnover ratio. These costs are constant on a per animal fed basis and are directly related to the total number of cattle fed. The feedlot turnover rate is the ratio of the total number of cattle fed per year to the number that could be fed at one time as reported by the feedlot operator. Assuming a 120 day feeding period, a turnover ratio of 3:1 would imply that the feedlot had operated at capacity levels throughout the year's operation. The observed turnover ratio in the sample feedlots varied from .5714 to 2.761. One feedlot reported a 3.7 turnover rate as the result of several animals being fed for a relatively short feeding period. To arrive at a comparable total cost value, all feedlot variable costs were adjusted to conform with a 1.0 turnover rate (Appendix D, Table V). These costs were then recorded in Table 7, and a total nonfeed cost value was determined for each feedlot.

The cost data supplied by the feedlot operators were not adjusted in any respect. Instead the questionnaires were scrutinized and either accepted as suitable for the analysis or removed from the sample. From the 48 feedlots available for study, two were rejected

directly because of a failure to supply cost information, and five were rejected because of their inclusion of other farming and business expenses with the feedlot cost data. These latter feedlots were indicated as being unsuitable when a series of least-squares curves were fitted to the scatter of data points representing each feedlot's respective total cost and capacity. They resulted in excessively high variations from the fitted functions. Further investigation verified the inclusion of nonfeedlot cost information.

Total Cost Curve

Two primary reasons for using the least-squares regression analysis technique for estimating the overall sample total cost function were to assist in the scrutinizing of feedlot cost information and to ascertain the possible shape of the long-run average cost curve. Several functional forms were fitted to the feedlot cost-output data, and statistical techniques were used to determine the form providing the best fit. The linear form $Y_i=\alpha+\beta X_i+U_i$ was found most suitable both prior to and after the removal of the five abnormal observations.

The least-squares technique involves the estimation of parameters for a given functional form such that the sum of the squares of the distances between the estimated function and the observed data points is a minimum. Using the linear form:

$$Y_i = \alpha + \beta X_i + u_i \qquad i = 1,2,\ldots n$$

where Y_i and X_i are the $_i$th observations, respectively, on the variables Y and X, α and β are parameters to be estimated, and u_i is the $_i$th disturbance

term, Huang [2] shows the mathematical derivation of the estimated parameters $\hat{\alpha}$ and $\hat{\beta}$ that satisfy the minimum requirements:

$$\text{minimize} \quad \Sigma d_i{}^2 = \Sigma[Y_i - (\hat{\alpha} + \hat{\beta}X_i)]^2$$

The necessary condition for a minimum are:

$$\frac{\partial}{\partial\hat{\alpha}} \Sigma d_i{}^2 = 0 \quad = 2\Sigma[Y_i - (\hat{\alpha} + \hat{\beta}X_i)] \; (-1)$$

$$\frac{\partial}{\partial\hat{\beta}} \Sigma d_i{}^2 = 0 \quad = 2\Sigma[Y_i - (\hat{\alpha} + \hat{\beta}X_i)] \; (-X_i)$$

These equations reduce to:

$$\Sigma Y_i - n\hat{\alpha} - \hat{\beta}\Sigma X_i = 0$$

$$\Sigma X_i Y_i - \hat{\alpha}\Sigma X_i - \hat{\beta}\Sigma X_i{}^2 = 0$$

Therefore:

$$n\hat{\alpha} + (\Sigma X_i) \; \hat{\beta} = \Sigma Y_i$$

$$(\Sigma X_i)\hat{\alpha} + (x_i{}^2) \; \hat{\beta} = \Sigma X_i Y_i$$

by Cramer's rule the system becomes:

$$\hat{\alpha} = \frac{(\Sigma Y_i)(\Sigma X_i{}^2) - (\Sigma X_i Y_i)(\Sigma X_i)}{n \; (\Sigma X_i{}^2) \quad - \quad (\Sigma X_i)^2}$$

$$\hat{\beta} = \frac{n(\Sigma X_i Y_i) - (\Sigma X_i) \; (\Sigma Y_i)}{n(\Sigma X_i{}^2) \quad - \quad (\Sigma X_i)^2}$$

which are the least-squares estimates of the parameters α and β in the functional form being fitted to the observations. The linear form $Y_i = \alpha + \beta X_i + u_i$ was used in the analysis.

Acçeptance of the nonhomogeneous linear total cost function provided a strong indication of economies of size relationships in the nonfeed costs of feedlot operations. A nonhomogeneous linear total cost

function has a marginal cost curve that is parallel to the abscissa (i.e. the marginal cost is the first derivative of the total cost function which is a constant for a linear function of the form $Y = \alpha + \beta X$). The average cost curve then becomes a rectangular hyperbola asymptotic to the marginal cost. Such a decreasing average cost curve indicates a cost advantage in favor of the larger feedlots.

In the estimated total cost function $\hat{Y} = \hat{\alpha} + \hat{\beta}X$, the parameters $\hat{\alpha}$ and $\hat{\beta}$ refer respectively to the fixed or "set-up" cost and variable plant costs. The spreading of $\hat{\alpha}$ over larger units of output is the source of economies of size. Therefore, a high fixed cost to variable cost ratio $(\hat{\alpha}/\hat{\beta})$ or $(\hat{\alpha}\ \hat{\beta}^{-1})$ would give a strong indication of economies of size and a tendency to industry locational centralization. A low $(\hat{\alpha}\ \hat{\beta}^{-1})$ would indicate the opposite. The least-squares estimated total cost functions of this study are similarly a good indication of these tendencies in Alberta beef cattle feedlots. The value of $\hat{\alpha}$ is low in the case of free disposal of fixed capital facilities for some of the relatively small but numerous feeders in Alberta. These feedlots were not represented in the feedlot study. The minimum size of feedlots in the sample survey was 250 head capacity.

The estimation of the total cost curve and resulting average cost curve was used only to serve as an indicator of possible economies of size in the cost data. The concept of economies of size is a long-run phenomenon which necessitates the comparison of a series of plants operating at different capacity levels. The most commonly used method of analysis involves the derivation of short-run average cost curves to represent

various plant sizes. The economies of size relationships are then demonstrated by a long-run average cost curve drawn as the locus of tangency points to the series of short-run average cost curves.

Short-Run Cost Curve Development

The focal point of the present study is the determination and quantification of the economies of size relationships in the nonfeed costs of the 41 feedlots accepted as being suitable for empirical analysis. The analysis necessitates the use of the long-run and short-run situations as represented by average cost curves. Short-run economies are the result of fuller utilization of the plant, whereas long-run economies result from efficiencies inherent in greater plant size. Therefore, in terms of the feedlot analysis, short-run efficiencies can be expected through increasing the feedlot turnover ratio. Long-run economies, should they exist, would be realized through increasing the physical scale of the feedlot operation.

Stratification of the feedlot sample data into seven size groups provided the basis for the development of the short-run cost curves. The stratified sample indicated in Table 8 was constructed in such a way as to minimize the range of feedlot sizes within any given stratum, while including sufficient observations to provide a realistic representation of the variation in nonfeed costs that exists within size groups. The number of feedlots in the larger size groups declined until only one feedlot was included in stratum seven. This procedure was judged acceptable because of the greater uniformity and precision in the records of the larger feedlots. However, the seventh stratum can serve only as an indicator of the possible level of the long-run average cost curve at that point because no measurement

Table 8

CALCULATION OF SAMPLE STRATUM INVESTMENT AND TOTAL COSTS

1.0 Turnover Rate

Data	Cattle Fed	Fixed Costs	Variable Costs	Total Cost	Total Investment
Stratum I					
19	250	4,211	1,635	5,846	10,705
27	300	3,484	938	4,422	10,981
10	350	1,800	2,056	3,856	6,325
9	400	5,430	4,808	10,238	13,100
28	400	3,353	2,151	5,504	15,844
35	400	3,867	1,480	5,347	7,400
46	400	3,635	2,135	5,770	9,750
Total	2,500	25,780	15,203	40,983	74,105
Average	(357)				(10,586)
Stratum II					
15	600	7,763	2,510	10,273	28,900
20	600	7,601	2,002	9,603	22,948
24	600	9,670	1,905	11,575	36,100
33	600	10,453	2,486	12,939	44,220
48	600	4,710	900	5,610	24,000
18	645	9,508	1,307	10,815	46,476
29	650	6,318	2,049	8,367	17,675
17	700	13,561	4,958	18,519	35,500
Total	4,995	69,584	18,117	87,701	255,819
Average	(624)				(31,977)
Stratum III					
5	750	4,564	1,925	6,489	23,170
25	800	10,459	5,972	16,431	35,483
44	800	10,393	4,539	14,932	40,415
4	900	5,770	3,467	9,237	15,850
21	900	10,706	1,948	12,654	86,891
Total	4,150	41,892	17,851	59,743	201,809
Average	(830)				(40,362)
Stratum IV					
3	1,000	11,331	7,196	18,527	33,300
13	1,000	13,121	2,793	15,914	44,532
23	1,000	7,714	2,204	9,918	35,820
39	1,000	8,954	2,998	11,952	10,500
16	1,100	11,867	2,219	14,086	42,680

Table 8 (continued)

	Cattle Fed	Fixed Costs	Variable Costs	Total Cost	Total Investment
8	1,200	17,049	6,681	23,730	74,540
14	1,200	12,615	5,678	18,293	29,450
Total	7,500	82,651	29,769	112,420	270,822
Average	(1,071)				(38,689)
Stratum V					
43	1,400	10,374	5,325	15,699	30,775
11	1,500	26,251	9,111	35,362	43,801
12	1,500	17,040	6,608	23,648	48,500
37	1,500	16,831	8,823	25,654	47,000
30	1,800	18,999	9,591	28,590	55,873
2	2,000	17,739	6,287	24,026	31,609
26	2,000	18,260	7,525	25,785	68,000
40	2,000	16,594	4,402	20,996	53,017
45	2,000	15,829	9,414	25,243	61,150
Total	15,700	157,917	67,086	225,003	439,725
Average	(1,744)				(48,858)
Stratum VI					
34	3,000	40,795	14,114	54,909	42,500
7	3,500	27,607	11,734	39,341	87,829
36	3,500	27,207	12,915	40,122	66,500
6	4,500	21,916	15,151	37,067	96,000
Total	14,500	117,525	53,914	171,439	292,829
Average	(3,625)				(73,207)
Stratum VII					
1	10,000	94,283	32,562	126,845	155,300

of variation is possible with only one observation. The relatively large gap in the range of data between the largest feedlot in stratum six and the stratum seven feedlot justified the use of two size groups. Similarly stratum one should serve primarily as an indicator of the level of the long-run average cost curve at the lower extreme. A high degree of variation was observed in the cost data supplied by these feedlots. Fluctuations resulting from a lack of detail in the accounting methods used would tend to average out. Free capital, on the other hand, would result in a downward bias of the average cost for the stratum. It is most likely that variations in cost data resulting from free capital exist in all but the larger feedlots. Engineers have developed what they refer to as the .6 rule for estimating the increase in capital cost resulting from an increase in capacity [3]. Briefly stated, the rule says that the increase in cost is given by the increase in capacity raised to the .6 power:

$$C_2 = C_1 \left(\frac{X_2}{X_1}\right)^{.6}$$ where C_1 and C_2 are the costs of two pieces of equipment and their respective capacities X_1 and X_2. The .6 rule reflects the physical relationship between volume and surface area. Applying this rule to the feedlot observations would suggest that a relatively narrow range of capital cost increases should be experienced with increases in the feedlot capacity.

In the absence of time series data indicating how feedlot size and nonfeed costs have varied over time, economies of size relationships were approximated using cross-sectional data. Therefore, throughout the analysis it was implicitly assumed that cross-sectional data representing various sizes of firms were a valid reflection of the variation in costs

that would result from changing the size of a given feedlot operation. In other words, it has been assumed that the representative firms constructed for each stratum have the same cost-size relationship as would be observed with a typical feedlot allowed to increase in size over time. This assumption was carried over into the development of the normative feedlot cost functions. Short-run average cost curves were not calculated for these functions; instead they were formed as the locus of the 3.0 feedlot turnover rate of utilization representing the lowest points on the short-run curves.

The composite firms for each stratum were calculated directly from the stratified sample and are shown in Table 8 as the total cattle fed and total cost for the 1.0 feedlot turnover rate. Average costs per head of cattle fed were obtained by division of the total stratum cost by the total number of cattle fed. The composite firm average number of cattle fed was calculated as the average for the stratum. These average cost points formed the lower limit of plant utilization (highest cost points) short-run average cost curve observations and are represented by the points labelled 1.0 in Figure 10. The remaining short-run average cost points for each composite firm were calculated by varying the feeding ratio as indicated in Table 9. Fixed costs remained constant for each level of plant utilization. Variable costs increased proportionately with the number of cattle fed as the turnover rate was increased.

Long-run average cost curves representing cost-size relationships are represented in Figure 10 as the locus of points of equal turnover rates for the seven composite firms. Two long-run curves (L_1L_1 and L_3L_3)

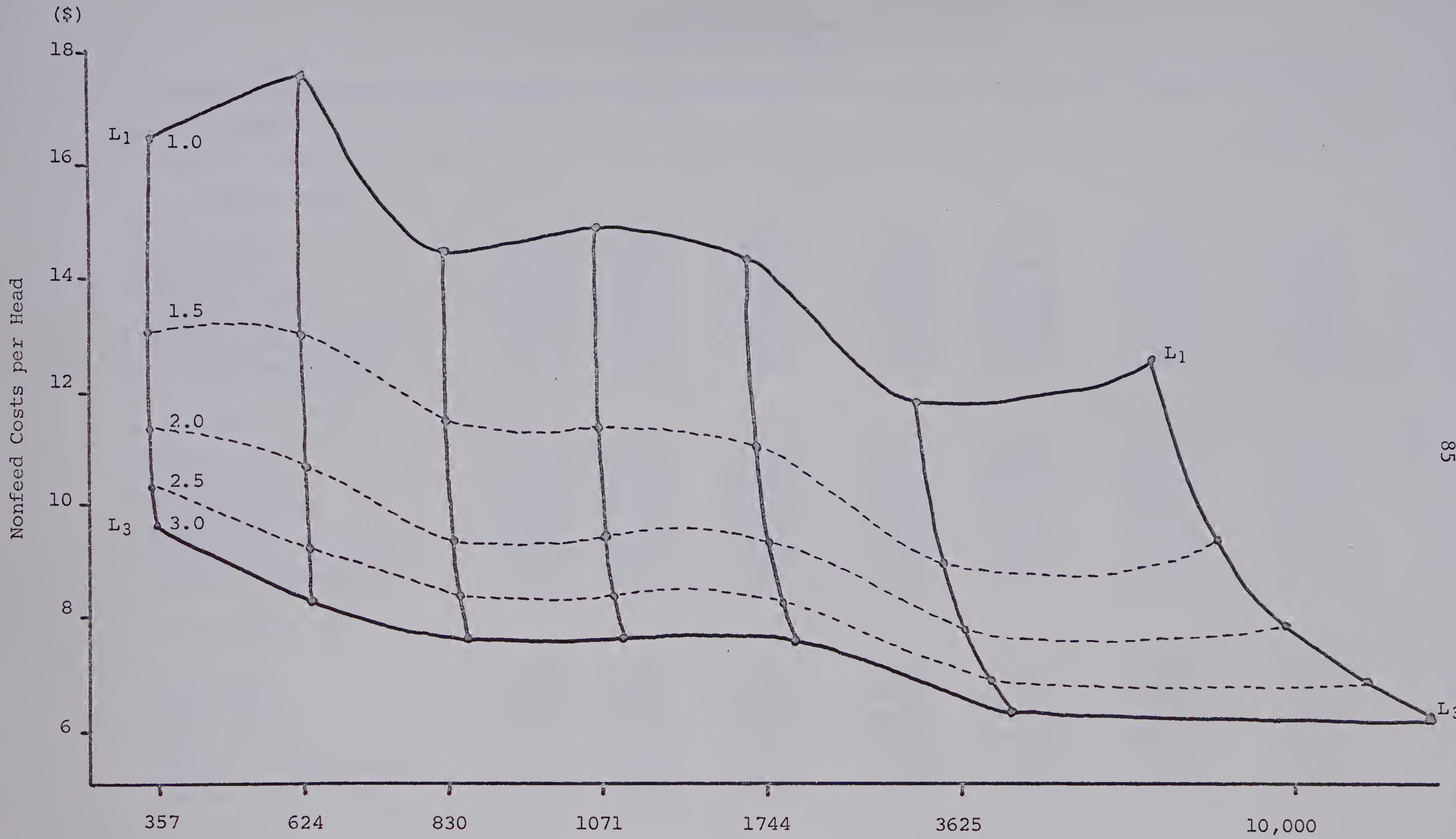

Figure 10

AVERAGE SHORT-RUN AND LONG-RUN RELATIONSHIPS BETWEEN NUMBER OF CATTLE FED AND NONFEED COSTS PER HEAD

Table 9

CALCULATION OF SHORT-RUN AVERAGE COST POINTS
FOR STRATIFIED SAMPLE

Stratum	I	II	III	IV	V	VI	VII
1.0 Turnover Rate							
Cattle Fed	2,500	4,995	4,150	7,500	15,700	14,500	10,000
Fixed Costs	25,780	69,584	41,892	82,651	57,917	117,525	94,283
Variable Costs	15,203	18,117	17,851	29,769	67,086	53,914	32,562
Total Costs	40,983	87,701	59,743	112,420	225,003	171,439	126,845
Average Cost per Head	16.39	17.56	14.40	14.99	14.33	11.82	12.68
Average Number Fed	(357)	(624)	(830)	(1,071)	(1,744)	(3,625)	(10,000)
1.5 Turnover Rate							
Cattle Fed	3,750	7,493	6,225	11,250	23,550	21,750	15,000
Fixed Costs	25,780	69,584	41,892	82,651	157,917	117,525	94,283
Variable Costs	22,804	27,176	26,776	44,653	100,629	80,871	48,843
Total Cost	48,584	96,760	68,668	127,304	258,546	198,396	143,126
Average Cost Per Head	12.96	12.91	11.03	11.32	10.98	9.12	9.54
Average Number Fed	(536)	(936)	(1,245)	(1,606)	(2,616)	(5,438)	(15,000)
2.0 Turnover Rate							
Cattle Fed	5,000	9,990	8,300	15,000	31,400	29,000	20,000
Fixed Costs	25,780	69,584	41,892	82,651	157,917	117,525	94,283
Variable Costs	30,406	36,234	35,702	59,538	134,172	107,828	65,124
Total Cost	56,186	105,818	77,594	142,189	292,089	225,353	159,407
Average Cost Per Head	11.24	10.59	9.35	9.48	9.30	7.77	7.97
Average Number Fed	(714)	(1,248)	(1,660)	(2,142)	(3,488)	(7,250)	(20,000)

Table 9 (continued)

Stratum	I	II	III	IV	V	VI	VII
2.5 Turnover Rate							
Cattle Fed	6,250	12,488	10,375	18,750	39,250	36,250	25,000
Fixed Costs	25,780	69,584	41,892	82,651	157,917	117,525	94,283
Variable Costs	38,008	45,292	44,627	74,422	167,715	134,785	81,405
Total Cost	63,788	114,876	86,519	157,073	325,632	252,310	175,688
Average Cost Per Head	10.21	9.20	8.34	8.38	8.29	6.96	7.03
Average Number Fed	(893)	(1,560)	(2,075)	(2,678)	(4,360)	(9,062)	(25,000)
3.0 Turnover Rate							
Cattle Fed	7,500	14,985	12,450	22,500	47,100	43,500	30,000
Fixed Costs	25,780	69,584	41,892	82,651	157,917	117,525	94,283
Variable Costs	45,609	54,351	53,553	89,307	201,258	161,742	97,686
Total Cost	71,389	123,935	95,445	171,958	359,175	279,267	191,969
Average Cost Per Head	9.52	8.27	7.67	7.64	7.63	6.42	6.40
Average Number Fed	(1,071)	(1,872)	(2,490)	(3,213)	(5,232)	(10,875)	(30,000)

have been indicated to show the effects of the rate of plant utilization and size of plant on costs per unit of output.

The development of normative feedlot cost functions was attempted by truncating the stratified sample data into quartiles and constructing composite firms for each stratum using three different combinations of quartiles. These were the low cost three fourths, the low cost one half, and the center one half of the observations in each of the five smaller size feedlot classifications. The two larger classifications were not truncated because of the limited number of observations in these strata, but did form part of the range of the cost functions developed. The calculation of the normative curves was similar to that used for the stratified sample (Appendix E). A summary of the various feedlot cost function short-run average cost points for the 3.0 feedlot turnover rate of utilization is presented in Table 10. Figure 11 presents these data graphically to show the relationship of the feedlot cost functions.

Results and Interpretations

The analysis of feedlot cost-size relationships performed in the present study reveals that the nonfeed costs of beef feedlot production, as experienced by Alberta feedlot operators, are a decreasing function of feedlot size. The decreasing function was found to apply throughout the range of feedlot sizes studied. Least-squares estimation of total nonfeed costs over the entire sample and for three different truncates of the data resulted in the acceptance of a linear function in each case. A summary of the least-squares results are presented in Table 11. The relatively high coefficient of determination (R^2) values indicates the significance of feedlot

Table 10

SUMMARY OF NORMATIVE FEEDLOT COST FUNCTION POINTS

FOR 3.0 FEEDLOT TURNOVER RATE

Quartiles	Stratum						
	I	II	III	IV	V	VI	VII
<u>Q1, Q2, Q3, Q4</u>							
Av. Number Cattle Fed	1,071	1,872	2,490	3,213	5,232	10,875	30,000
Av. Cost Per Head ($)	9.52	8.27	7.67	7.64	7.63	6.42	6.40
<u>Q1, Q2, Q3</u>							
Av. Number Cattle Fed	1,050	1,848	2,514	3,180	5,313	10,875	30,000
Av. Cost Per Head ($)	8.18	7.00	6.67	6.41	6.93	6.42	6.40
<u>Q1, Q2</u>							
Av. Number Cattle Fed	1,086	1,836	2,475	3,075	5,499	10,875	30,000
Av. Cost Per Head ($)	7.44	6.64	5.36	5.88	7.01	6.42	6.40
<u>Q2, Q3</u>							
Av. Number Cattle Fed	1,086	1,833	2,601	3,300	6,000	10,875	30,000
Av. Cost Per Head ($)	8.57	7.87	7.27	7.04	6.75	6.42	6.40

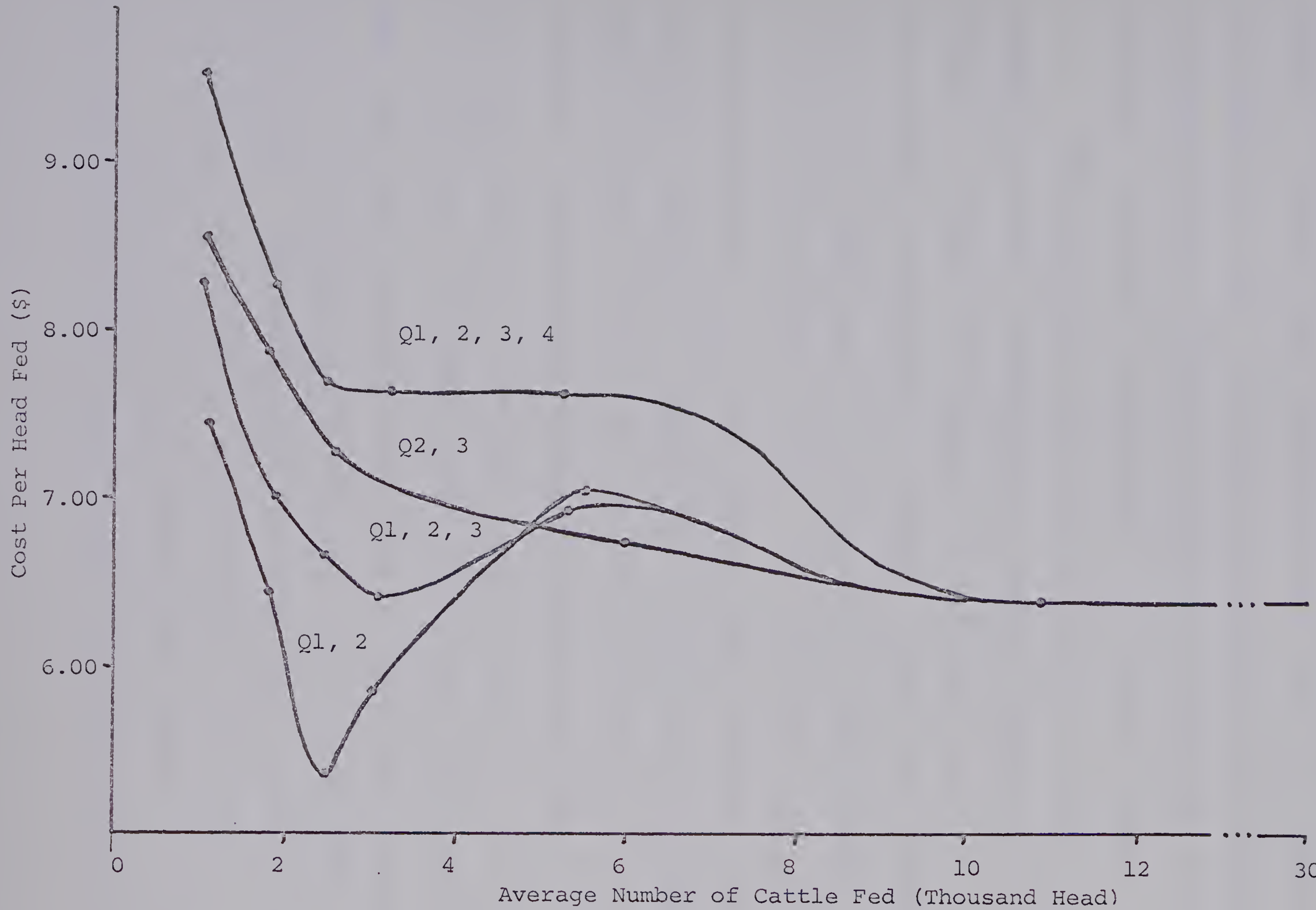

Figure 11

NORMATIVE FEEDLOT COST FUNCTIONS

size in explaining the variation in the total nonfeed costs of beef feedlot operation. By comparing the calculated t-values to t-table values corresponding to the respective degrees of freedom for each function the estimated slope coefficients were found to be significant at the one percent level. Therefore, the estimated linear nonhomogeneous cost functions may be accepted as reasonable representations of the actual cost-output relationships for the feedlot and normative samples.

The average cost curves for the functions of Table 11 decrease throughout the range of observations and therefore support the theoretical development of Chapter 3 and suggest that economies of size are present. Further support of this concept is indicated by the ratio of fixed:variable costs ($\hat{\alpha}\ \hat{\beta}^{-1}$). High values were obtained for the overall sample function and normative cost functions; however, $\hat{\alpha}\ \hat{\beta}^{-1}$ decreased as the number of low cost observations in the data increased while the number of high cost observations decreased. The significance of these results strongly suggests economies of size in the nonfeed costs; moreover, they imply that economies of size are not so pronounced in the low cost half of the cost data of each stratum as in the middle or upper quartiles. The low values of $\hat{\alpha}$ in the case of the smaller feedlot observations could indicate that either free capital or errors in reporting the fixed costs were present. Similarly underestimated capital investments could explain other low cost extreme values. The extreme fixed cost values could also be the result of overestimation of the values of feedlot equipment and facilities.

Interpretation of the estimated linear feedlot cost functions can be made only within the relevant range of the data observed, and then

Table 11

SUMMARY OF LEAST-SQUARES ESTIMATED TOTAL COST FUNCTIONS
FOR 1.0 FEEDLOT TURNOVER RATE

Quartile Combination	Equation	R^2 Percent	t-value	Level of Significance	$\hat{\alpha}\ \hat{\beta}^{-1}$
Q1, 2, 3, 4	Y = 2,950 + 11.85 X (.552)	92.2	21.47	**	249:1
Q1, 2, 3	Y = 1,283 + 12.02 X (.514)	94.64	23.4	**	107.1
Q1, 2	Y = 618 + 12.15 X (.601)	94.68	20.24	**	51.1
Q2, 3	Y = 1,982 + 11.90 X (.614)	94.95	19.38	**	166.1
FOR 2.0 FEEDLOT TURNOVER RATE					
Q1, 2, 3, 4	Y = 3,984 + 7.56 X	92.9	22.62	**	527:1
Q1, 2, 3	Y = 1,776 + 7.67 X	95.4	25.38	**	232:1
Q1, 2	Y = 952 + 7.75 X	95.6	22.32	**	123:1
Q2,3	Y = 1,427 + 4.30 X	91.8	14.97	**	332:1

the extremes should not be given too much emphasis. The least-squares technique produces a minimum variance; however, it is possible for a large variation between data points and the estimated function to occur at the extremes. In other words, the average cost curve could be tending upward at the extreme right hand values and not affect the estimated function. It is also possible for increasing and decreasing portions of the data to exist within the range of observations.

The least-squares estimated functions are a short-run phenomenon and cannot be used other than to show that economies of size are present. The analysis of economies of size relationships requires the development of a long-run average cost curve formed as the locus of tangency points to short-run curves representing various sizes of plants. The short-run analysis was facilitated by developing short-run average cost points representing various rates of plant utilization for seven different sizes of plants. The resulting long-run average cost curves formed by joining points of equal turnover rates indicated economies of size over the range of data. At the 1.0 turnover rate the curve demonstrated rising and falling portions. As the rate of utilization reached capacity levels, the long-run curve shifted downward and tended to become flat at the fifth stratum.

The long-run average cost curves for the truncated samples (Figure 12) followed a similar pattern, except in the case of the middle two quartiles curve. This curve tended to remain smooth throughout its range and exhibited those characteristics expected from theoretical considerations. When the high cost quartile of the sample was replaced by

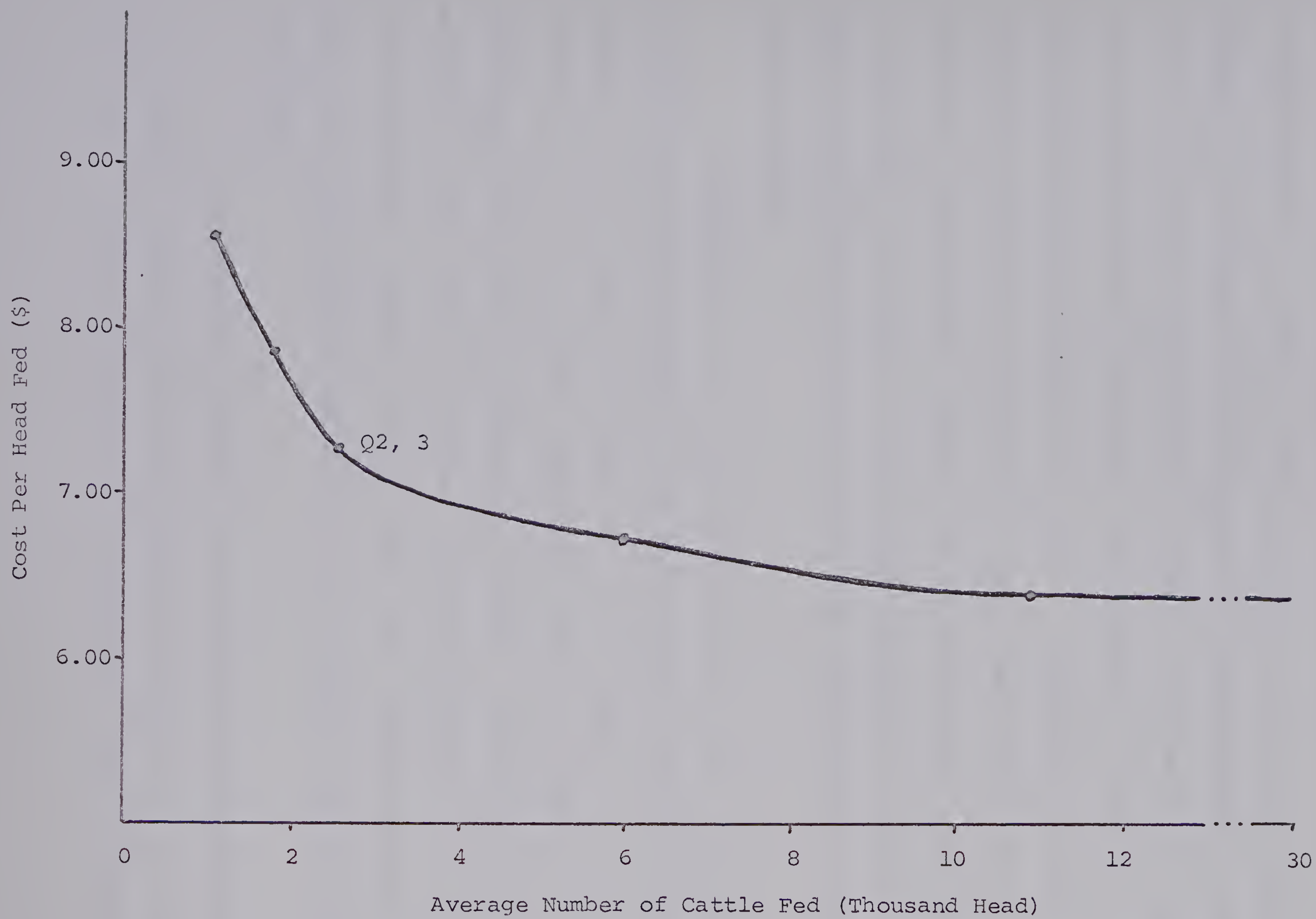

Figure 12

LONG-RUN AVERAGE COST CURVE REPRESENTING THE CENTER QUARTILES OF THE FEEDLOT OBSERVATIONS

the low cost quartile, the second and third strata declined rapidly. Exclusion of the low cost one quarter of the data resulted in an increasing portion of the long-run average cost curve at the second stratum. Reasons for these results are similar to those explained in the least-squares estimates. The existence of free capital and underestimation of fixed costs are most likely responsible for the very low values of the long-run curve in the second and third strata. Overestimation of fixed costs could explain the increasing portion of the curve. Considering the above possible reasons for variations in the cost data within each stratum, and the confirmation of the theoretical shape of the long-run average cost curve by the middle half of the data, it would appear reasonable to accept the middle two quartiles of the data as being more representative of the actual feedlot situation.

A comparison of the long-run average cost curve calculated for the second and third quartiles and the least-squares estimated function marginal cost curve shows the former to be in the range of $11.82 to $12.68 in the last two strata, respectively, while the marginal cost (first derivative of the total cost function) is $11.90. The average cost curve developed by least-squares approaches the $11.90 marginal cost; therefore, the two techniques suggest a similar level of the long-run average cost curve at the extreme end of the data for a 1.0 turnover rate of feedlot utilization.

A very substantial result of the analysis was the importance of the feedlot turnover rate in determining the nonfeed cost per head of cattle fed. The slope of the short-run average cost curves, relative to

the slope of the long-run average cost, indicates higher cost savings resulting from greater plant utilization than from increased plant size. As the turnover rate was increased, the average cost per animal fed decreased more rapidly than was realized through increasing plant size and holding the rate of utilization constant. Therefore, feedlot operators must be more concerned with the number of cattle fed per year than with the number that could be fed at any one time.

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CHAPTER VI

IMPLICATIONS AND CONCLUSIONS

Implications

Alberta is the largest beef producing province in Canada, accounting for 37.5 percent of the nation's total supply of 2.87 million beef cows [2]. Projection figures estimate that the land available, if fully utilized, could support 1.75 million beef cows or an increase of approximately 50 percent in beef cow numbers. The continued development of the Alberta beef feedlot industry will depend upon the demand for beef, the available supply of beef industry inputs, and inter-regional competition.

The demand for beef in Canada is expected to increase 50.9 percent over the 1965 to 1980 period. This estimate has been based on present trends in beef consumption, population growth, and a continuation of existing economic conditions. Per capita consumption has increased steadily along with consumer incomes since 1959.

Beef must compete with other meats in the marketplace. Improvements in the quality or price of other meats will result in decreased consumption of beef unless a similar change occurs with beef. A large increase in the price of beef would serve only to increase consumer resistance and limit the growth of the beef industry.

The two largest cost components of beef feedlot production are feeder cattle and feed grains. Alberta has a large surplus of feed grains which provides means for increased cattle feeding. Projected forage supplies indicate a 50 percent increase in cattle production is

possible by 1980. Therefore, the feedlot industry of the province can expect approximately 1.5 million feeder cattle per year to be available for feeding.

Regional competition will be the most limiting factor in the expansion of Alberta's cattle feeding industry. Feedlot operators compete on a Canadian market for feeder cattle and then sell their slaughter animals at prices determined by a North American market. The present low price of available feed grains has given the Alberta cattle feeder a competitive advantage in the feeder cattle market. A return to normal feed grain prices would remove some of this cost advantage. If Alberta cattle feeders are to maintain a competitive advantage, they must increase feedlot production efficiency to offset the effects of rising feed grain prices.

Competition for eastern Canadian or United States markets requires that the total combined cost of supplying meat to these markets be less for the Alberta product than for producers in other regions. In other words, Alberta feedlot operators must supply processed beef to other regions at a lower price than it can be supplied by competing regions after paying the cost of feeder cattle, freight, feed and feedlot services. Of these costs, only the price of feedlot services can be affected substantially by the cattle feeder.

The results of this study indicate that Alberta's competitive position in the processed beef market, assuming constant beef processing charges, can be enhanced by using larger, more highly specialized beef feedlots and relatively small farm feedlots. With a source of free capital in feedlot facilities and the economies experienced through more

efficient use of off-season or supplemental labor, the small farm feedlot becomes highly competitive. The feedlot also provides the small operator with an additional market for surplus grains.

Economies of size within an industry tend to centralize processing facilities to minimize plant production costs. Verification of economies of size in Alberta beef feedlots indicates that a trend to larger feedlots is imperative. This trend will not necessarily extend to small farm feedlots because they would stand to gain very little in the way of cost reducing benefits. Therefore, it is most likely that larger beef feedlots will tend to centralize while small farmer owned enterprises will remain highly decentralized.

Centralization of cattle feeding can be expected to take place in grain producing regions in close proximity to packing plants. These areas at present include Edmonton, Red Deer, Calgary, and Lethbridge. Additional feeding areas can be expected to develop as packing plants become more decentralized. Economies of size in beef processing plants are now reached at much lower plant volumes as the result of automation and specialization of plant facilities. Decentralization of packing plants has been taking place in the United States for the past few years [1]; the trend could reach Alberta in the near future. Additional packing plants could be located in the smaller trading centers of the province. These locations may possibly include Stettler, Lloydminster, Grande Prairie, Camrose, Medicine Hat, and others.

Areas of centralization in the beef feeding industry will be based on the available supply of feed grains and transportation costs

involved in shipments of feed grains, feeder cattle, and slaughter animals. Feeder cattle production requires abundant sources of relatively inexpensive forage; therefore, it is concentrated in the mixed farming and range areas of the province. Feeder cattle may be transported over long distances without costly shrinkage losses and shipping charges.

The results of this study indicate two alternatives available to feedlot operators for reducing their cost of production. In order of importance these alternatives are: (1) the rate of feedlot capacity utilization, and (2) the scale size of the business. The importance of the feedlot turnover rate was indicated clearly in Figure 10 by the steepness of the short-run curves. The slope of these curves indicates that a substantial reduction in the average nonfeed cost per animal fed can be expected for any size of feedlot as the total number of cattle fed during the year is increased. The amount of this reduction in average costs for a particular feedlot is determined by the level of fixed costs involved in the business. Producers with a limited capital investment or free capital cannot expect to reduce their average cost to any great extent through increasing the rate of feedlot u tilization. When the ratio of fixed costs to variable costs is low, economies of size tend to disappear. When the operators who originated their feedlot undertaking with a limited capital investment begin to account for the cost of labor and expand their facilities, their ratio of fixed costs to variable costs increases thus giving them more incentive to increase the rate of utilization and size of the feedlot. A general substitution of

capital for labor is expected to occur as the uncertainty costs of labor and wage rates increase. Uncertainty costs are those associated with the unpredictable nature of operating a business with a large number of employees.

Alberta's cattle feeding industry can be expected to place increased emphasis on a high degree of feedlot utilization as feedlots increase in size and producers are faced with larger capital investments. However, three major factors could limit the extent to which increased feedlot utilization rates may be experienced and thus prevent the most efficient level of production from being attained. These factors are capital rationing, the supply of feeder cattle, and the availability of forage.

Cattle feeding has a high working capital requirement and a low rate of return. Therefore, the number of cattle that may be fed during one year by a producer depends on his ability to provide sufficient working capital to purchase feeder cattle and feed for the duration of the feeding period (60 to 120 days for heavy feeders). Should the producer need to borrow his working capital, he may find periods when only limited amounts of capital are available.

The second and perhaps most limiting factor in the rate at which feedlot facilities may be utilized is the supply of feeder cattle. Projections of forage requirements indicate a total of 1.75 million cows could be stocked on Alberta pastureland by 1980 provided these pastures are improved through advanced management, reseeding and fertilization practices. A high rate of feedlot utilization requires a large even

flow of feeder cattle throughout the year. The present production practices in the beef industry result in periods of surpluses and shortages of feeder cattle. This condition is caused by the majority of beef animals being born in the spring. Feeder calves are either sold in the fall or held until spring to be sold as yearlings. Consequently, the flow of feeder cattle through the feedlots to packing houses is distributed unevenly. Fluctuations in the supply of both feeder and slaughter cattle result in cost and price instability—an important cause of risk in cattle feeding. This situation can be resolved only through a system of spring and fall calving and an increase in the flow of information to each stage of the production cycle. Producers would then be able to supply feeder cattle more uniformly throughout the year, thus enabling the feedlot industry to work on a greater rate of utilization. The future development of the cattle feeding industry in Alberta depends largely on the industry's competitive position. The feedlot processing costs (nonfeed costs) will be the deciding factor in determining the regional location of beef feedlot production in Canada. Alberta cattle feeders will need to increase their production efficiency by taking advantage of all of the cost reducing techniques available to them. In this study of Alberta feedlots the size of the feedlot business was found to be an important factor in establishing the nonfeed cost per animal fed.

Conclusions

This study of beef feedlots in Alberta was established in

1967 as a joint effort of the Departments of Agricultural Economics, Animal Science, and Agricultural Engineering of The University of Alberta. Letters were sent to a sample of feedlot operators in the province asking for their cooperation in the study. Those producers willing to participate were mailed copies of a comprehensive questionnaire designed by Dr. H. C. Love of the Department of Agricultural Economics. A personal interview was conducted with each participant to assist in the completion of the questionnaires.

Agricultural producers, in general, have been faced with declining profit margins. Input prices have increased at a greater rate than prices received for farm goods. Although agricultural output has increased and total farm incomes have risen when the result is discounted to take care of the effects of inflation, a reduction in farm purchasing power has taken place. The Alberta beef feedlot operator has been caught in a market price squeeze. Because beef prices are determined largely by the United States market, the emphasis in this study was to investigate possible means of increasing Alberta beef feedlot production efficiency. A reduction in the average cost of feedlot operation would give Alberta producers a competitive advantage in the beef market.

Production efficiency involves the maximization of the output:input ratio. In beef feedlot operations the output is in terms of slaughter animals, whereas inputs include feeder cattle, feed, and nonfeed items. Increased production efficiency must take place in the nonfeed inputs. Feeder cattle and feed costs are primarily a function of supply and demand conditions and do not come under the control of the feedlot operator. Therefore, the

focal point of this study was the nonfeed costs of beef feedlot operation in Alberta.

The objectives of the study were (1) to determine the internal physical economies of size associated with beef feedlot capacity in the province of Alberta, (2) to derive a long-run average cost curve to represent total nonfeed costs per head of feedlot capacity as a function of feedlot size, and (3) to develop normative long-run average cost curves to show degrees of cost efficiency within feedlot size classifications. These objectives were set out as a means of guiding the analysis of production efficiency in Alberta beef feedlots. In seeking to develop normative cost functions, the primary concern was to develop a benchmark for policy implications.

The data used in this study were obtained primarily from the 1967 survey of Alberta feedlots conducted by Dr. H. C. Love. A copy of the questionnaire used in this survey has been presented in Appendix G. These questionnaires provided a profile of information on feedlot operation for a reasonable cross section of the range of feedlot sizes operating within the province. The questionnaires were scrutinized to determine those observations suitable for analysis, and the cost information was adjusted to conform with a 1.0 feedlot turnover rate. Two analytical techniques were used to discover cost-output relationships in the data. The least-squares technique was used to estimate total cost functions, and the synthetic firm budgeting technique was used to develop short-run and long-run average cost curves. The data were stratified according to a feedlot capacity size criterion, and each stratum was truncated into

quartiles. This latter technique was found useful in establishing the normative feedlot cost functions.

The results of the least-squares estimation of total cost curves indicated that the total nonfeed cost per animal fed is a linear function of the feedlot capacity (Table 11). The estimated functions for different quartile combinations had relatively high coefficients of determination and were significant at the one percent level. These functions indicated that the high cost quartile had a greater ratio of fixed to variable costs and that this ratio declined with the lower cost quartiles.

The synthetic firm budgeting technique was used to develop short-run average cost curves for each stratum of the stratified sample. These curves were developed as a series of points representing variations in the feedlot turnover rate (Figure 9). The short-run curves decreased rapidly as the turnover rate increased for each size classification. Long-run average cost curves were developed as the locus of short-run average cost points of equal turnover rates. The long-run average cost curve representing the 1.0 feedlot turnover rate at first increased, then decreased from 624 to 830 head capacity, increased from 830 to 1,071 head capacity and then decreased. When the feedlot turnover rate was increased to capacity levels (3.0 turnover rate), the long-run average cost curve decreased from 357 to 830 head capacity, remained relatively constant to 1,744 head capacity, and then decreased.

The results of the synthetic firm approach used in developing the normative cost functions are shown in Table 10 and Figure 11. These

curves indicate that inclusion of the high cost quartile with the other three quartiles produced a rising portion in the long-run average cost curve. The center two quartiles resulted in a relatively smooth declining long-run average cost curve throughout the range of data observed. However, when the low cost quartile was included in the absence of the high cost quartile, the long-run average cost curve declined sharply then increased prior to levelling off. In all cases the curves converged at the stratum six observation because this stratum and the seventh stratum were not truncated. The limited number of observations in the larger feedlot size classifications prevented the development of normative curves for this portion of the data. Moreover, less error in the cost information supplied by the larger firms suggests only one curve for this region of the data.

From the empirical results of this study it can be concluded that the total cost function representing the range of feedlot sizes studied is a linear nonhomogeneous function. The least-squares analysis produced a linear nonhomogeneous function for each combination of data analyzed. Because the average cost curve resulting from a linear cost function declines throughout its range, the synthetic firm budgeting technique verified the least-squares results for the 3.0 turnover rate. This latter technique also produced a smooth declining average cost curve for the second and third quartiles of the normative cost curve analysis.

The normative cost curves developed as combinations of high and low cost quartiles of the data verified the importance of the fixed cost:variable cost ratio in determining the extent of economies of size

relationships within the range of data. The low cost quartiles produced average cost curves that dropped sharply at the lower capacity levels then returned to higher levels as the feedlot capacity increased. These same quartiles resulted in the lowest ratio of fixed costs to variable costs in the least-squares analysis. A similar analogy can be made for other quartile combinations.

The normative curve developed for the second and third quartiles of the feedlot data is the most acceptable as a benchmark for policy formulation. This curve is not influenced by possible extremes in data reporting or sources of free capital and can therefore be considered as a reliable indicator of the relationships between size and nonfeed costs per animal fed in Alberta feedlots.

The size of the feedlot enterprise becomes an important consideration once the feedlot capacity limit is approached. Over the range of data studied the larger feedlots experienced a reduction in nonfeed costs of approximately four dollars per animal fed. The normative cost curve development indicated a greater variation in costs within each stratum than between strata. This variation indicates that factors other than size are of considerable importance in determining the nonfeed costs of feedlot operation. These factors include the length of the feeding period, the feedlot turnover rate, and the choice of equipment and facilities used in the feedlot enterprise. Genetic improvements in the beef animal as well as new feeding and management techniques could contribute significantly to increasing the overall production efficiency in Alberta beef feedlots.

Further Research

The analysis of economies of size relationships presented in

this thesis was based on the average cost information of groups of similar sized feedlots in Alberta. These averages do not indicate the typical situation experienced by the group. Feedlots within any given size classification differ in their ratio of fixed to variable costs and, therefore, in their use of capital and labor to accomplish the feedlot function. The results of this study should provide a benchmark for comparative purposes rather than an indication of specific cost-output relationships.

This study suggests further research is needed to determine (1) the interregional competition among classes of livestock and (2) the interregional competition in the beef industry. A regional analysis should also be made to determine Alberta's competitive position with other provinces as well as with regions in the United States.

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APPENDICES

APPENDIX A

APPENDIX B

APPENDIX A

Alberta Cattle and Calf Marketing - 1964 to 1968

	Terminal Markets	Direct to Packing Plants	Direct on Export	Ctry. Pts. in other Prov.	Total Marketing
1968	761,769	715,617	7,826	59,895	1,545,107
1967	719,555	644,098	1,707	58,776	1,424,136
1966	789,606	602,890	14,293	68,449	1,475,238
1965	744,407	583,786	27,035	54,836	1,410,064
1964	624,865	496,912	7,369	57,888	1,187,034

Alberta Cattle Marketing 1964 to 1968

	Terminal Markets	Direct to Packing Plants	Direct on Export	Ctry. Pts. in other Prov.	Total Marketing
1968	595,993	686,343	6,295	9,195	1,297,826
1967	557,854	610,954	1,609	12,014	1,182,431
1966	629,634	560,852	6,304	10,367	1,207,157
1965	608,357	530,892	13,914	10,074	1,163,237
1964	502,754	449,554	7,057	8,513	967,878

Alberta Calf Marketing 1964 to 1968

	Terminal Markets	Direct to Packing Plants	Direct on Export	Ctry. Pts. in other Prov.	Total Marketing
1968	165,776	29,274	1,531	50,700	247,281
1967	161,701	33,144	98	46,762	241,705
1966	159,972	42,038	7,989	58,082	268,081
1965	136,050	52,894	13,121	44,762	246,827
1964	122,111	47,358	312	49,375	219,156

APPENDIX B

PERCENTAGE DISTRIBUTION OF ALBERTA CATTLE AND CALF MARKETING 1964 to 1968

Cattle and Calves	1968	1967	1966	1965	1964
Terminal Markets	49.3	50.5	53.5	52.8	52.6
Direct to Packing Plants	46.3	45.2	40.9	41.4	41.9
Direct on Export	.5	.2	1.0	1.9	.6
Ctry. Pts. in other Prov.	3.9	4.1	4.6	3.9	4.9
Cattle					
Terminal Markets	45.9	47.2	52.2	52.3	51.9
Direct to Packing Plants	52.9	51.7	46.5	45.6	46.5
Direct on Export	.5	.1	.5	1.2	.7
Ctry. Pts. in other Prov.	.7	1.0	.8	.9	.9
Calves					
Terminal Markets	67.0	66.9	59.7	55.1	55.7
Direct to Packing Plants	11.9	13.7	15.7	21.5	21.6
Direct on Export	.6	.0	2.9	5.3	.2
Ctry. Pts. in other Prov.	20.5	19.4	21.7	18.1	22.5

APPENDIX C

APPENDIX C

FEEDLOT FACILITIES AND EQUIPMENT
(Number Reporting)

	Number of Feedlots
Type of Pens	
Wood Post and Planks	42
Wood Posts and Cable	1
Wood Post and Rail	5
Type of Pen Surfacing	
Dirt	41
Concrete	1
Concrete (Feeding Apron Only)	6
Natural Shelter	
Valley	4
Trees or Brush	9
Cutbanks or Coulee	3
Shelterbelt	14
Sidehill	1
Windbreak Shelters	
Solid Fence	8
Slatted Fence	34
Height of Windbreak Fences	
5 feet	1
6 feet	2
7 feet	5
8 feet	28
9 feet	6
10 feet	1
Feedlot Buildings	
Hospital Building or Shed	20
Hospital Pens	1
Cattle Sheds	11
Feeding Sheds	2

APPENDIX C (continued)

	Number of Feedlots
Storage Facilities	
Steel Bins	24
Wood Bins	29
Bulk Feed Tank	2
Pit Silo	7
Hay Shed	4
Elevator Building	9
Fenceline Bunk Feeders	
a) Construction	
Wood	14
Concrete	4
Wood and Concrete	10
b) Method of Filling	
Feed Wagon	19
Truck mounted mixer Box	6
By Hand	3
In Pen Bunk Feeders	
a) Construction	
Wood	15
Concrete	2
b) Method of Feeding	
Feed Wagon	4
Truck mounted mixer Box	1
By Hand	11
Auger System	1
Self Feeders	
Wood	28
Wood and Concrete	3
Scales	
Livestock	21
Truck	18

APPENDIX D

APPENDIX D

Table I

CALCULATION OF FIXED INTEREST

(interest at six percent)

Observation	Bldg.	Pens	Wells & Water	Truck - Tractor	Sta.** Eq.	Port.** Eq.	Misc.** Eq.	Total** Inv.	Investment Cost
1	20,000	45,000	4,400	-	60,000	24,500	1,400	155,300	9,318
2	3,116	7,666	5,730	8,241	1,993	1,543	3,320	31,609	1,897
3	6,000	8,000	2,000	-	2,300	10,000	5,000	33,300	1,998
4	500	6,600	500	4,000	-	4,250	-	15,850	951
5	3,500	600	2,070	13,000	1,750	2,250	-	23,170	1,390
6	8,000	50,000	6,000	4,000	12,000	4,000	12,000	96,000	5,760
7	15,000	10,000	2,000	36,583	4,626	9,620	10,000	87,829	5,270
8	31,420	17,400	2,400	4,430	12,610	3,780	2,500	74,540	4,472
9	2,000	800	1,000	5,000	1,200	3,000	100	13,100	786
10	750	750	1,725	-	1,700	1,400	-	6,325	380
11	27,589	-	-	11,450	3,795	600	367	43,801	2,628
12	10,000	32,000	4,000	-	-	2,500	-	48,500	2,910
13	10,000	6,000	2,000	15,332	4,500	6,700	-	44,532	2,672
14	3,000	11,350	3,500	4,800	3,500	3,300	-	29,450	1,767
15	9,000	5,000	5,000	5,000	300	4,600	-	28,900	1,734
16	5,080	11,000	2,200	15,200	3,200	2,700	3,300	42,680	2,561
17	6,000	10,000	1,500	10,000	4,000	3,000	1,000	35,500	2,130
18	10,096	10,100	900	11,916	13,006	458	-	46,476	2,789
19	2,349	1,215	1,091	3,317	365	2,368	-	10,705	642
20	12,383	2,919	1,501	3,082	-	3,063	-	22,948	1,377
21	18,600	3,500	3,000	12,000	3,200	6,591	-	86,891	5,213
22*	8,700	15,000	1,000	12,000	1,475	4,700	-	42,875	2,572
23	11,300	2,300	600	16,400	1,545	3,675	-	35,820	2,149
24	3,000	-	750	11,200	2,100	19,050	-	36,100	2,166
25	6,545	5,365	1,760	15,226	2,681	3,906	-	35,483	2,129
26	8,000	20,000	5,000	23,500	5,400	6,100	-	68,000	4,080
27	1,500	2,000	1,100	2,600	1,480	2,301	-	10,981	659
28	2,000	2,700	1,500	6,300	-	3,344	-	15,844	951
29	-	5,000	800	7,000	375	4,500	-	17,675	1,060

Table I (continued)

Observation	Bldg.	Pens	Wells & Water	Truck - Tractor	Sta. Eq.	Port. Eq.	Misc. Eq.	Total Inv.	Investment Cost
30	6,510	6,510	4,500	9,743	15,000	13,610	-	55,873	3,352
32*	-	32,000	-	11,400	1,500	200	-	45,100	2,706
33	20,000	10,000	120	1,100	5,000	8,000	-	44,220	2,653
34	1,000	5,000	4,000	26,000	2,500	4,000	-	42,500	2,550
35	500	2,500	1,000	-	400	2,000	1,000	7,400	444
36	3,000	24,000	11,000	20,500	6,000	2,000	-	66,500	3,990
37	30,000	5,000	1,000	5,000	4,000	2,000	-	47,000	2,820
39	500	2,500	2,500	3,000	-	2,000	-	10,500	630
40	25,000	13,436	3,279	3,750	800	252	6,500	53,017	3,181
41*	2,500	5,000	3,500	22,000	6,300	4,800	-	44,100	2,646
42*	17,291	13,231	3,879	7,850	31,890	6,007	-	80,148	4,809
43	150	26,000	1,050	3,500	75	-	-	30,775	1,846
44	12,000	2,000	2,000	19,000	-	5,415	-	40,415	2,425
45	4,000	32,500	4,500	5,300	12,050	2,800	-	61,150	3,669
46	1,500	2,200	800	4,800	150	300	-	9,750	585
48	12,000	5,000	1,000	3,500	1,500	1,000	-	24,000	1,440

* These observations were eventually dropped from the sample.

** Sta. Eq. Stationary Equipment.

Port. Eq. Portable Equipment.

Misc. Eq. Miscellaneous Equipment.

Total Inv. Total Investment.

APPENDIX D

Table II

CALCULATION OF DEPRECIATION

Observation	Bldg. @ 5%	Pens @ 5%	Wells & Water @ 10%	Truck - Tractor @ 15%	Sta. Eq. @ 10%	Port. Eq. @ 15%	Misc. Eq. @ 10%	Total Depreciation
1	1,000	2,250	440	-	6,000	3,675	140	13,505
2	155	383	573	1,236	199	231	332	3,109
3	300	400	200	-	230	1,500	500	3,130
4	25	330	50	600	-	637	-	1,642
5	175	30	207	1,950	175	337	-	2,874
6	400	2,500	600	600	1,200	600	1,200	7,100
7	750	500	200	5,487	462	1,443	1,000	9,842
8	1,571	870	240	664	1,261	567	250	5,423
9	100	40	100	750	120	450	10	1,570
10	37	38	172	-	170	210	-	627
11	1,380	-	-	1,717	380	90	37	3,604
12	500	1,600	400	-	-	375	-	2,875
13	500	300	200	2,300	450	1,005	-	4,755
14	150	568	350	720	350	495	-	2,633
15	450	250	500	750	30	690	-	2,670
16	254	550	220	2,280	320	405	330	4,359
17	300	500	150	1,500	400	450	100	3,400
18	505	505	90	1,787	1,301	59	-	4,274
19	117	60	109	497	36	355	-	1,174
20	619	145	150	462	-	459	-	1,835
21	930	175	300	1,800	320	988	-	4,513
22*	435	750	100	1,800	148	705	-	3,938
23	565	115	60	2,460	154	552	-	3,906
24	150	-	75	1,680	210	2,857	-	4,972
25	327	268	176	2,284	268	586	-	3,909
26	400	1,000	500	3,525	540	915	-	6,880
27	75	100	110	390	148	445	-	1,268
28	100	135	150	945	-	501	-	1,831
29	-	250	80	1,050	38	675	-	2,093

Table II (continued)

Observation	Bldg. @ 5%	Pens @ 5%	Wells & Water @ 10%	Truck - Tractor @ 15%	Sta. Eq. @ 10%	Port. Eq. @ 15%	Misc. Eq. @ 10%	Total Depreciation
30	325	325	450	1,461	1,500	2,041	-	6,102
32*	-	160	-	1,710	150	30	-	2,050
33	1,000	500	12	165	500	1,200	-	3,377
34	50	250	400	3,900	250	600	-	5,450
35	25	125	100	-	40	300	100	690
36	150	1,200	1,100	3,075	600	300	-	6,425
37	1,500	250	100	750	400	300	-	3,300
39	25	125	250	450	-	300	-	1,150
40	1,250	671	328	562	80	37	650	3,578
41*	125	250	350	3,300	630	720	-	5,375
42*	864	661	388	1,177	3,189	901	-	7,180
43	8	1,300	105	525	8	-	-	1,946
44	600	100	200	2,850	-	811	-	4,561
45	200	1,625	450	795	1,205	420	-	4,695
46	75	110	80	720	15	45	-	1,045
48	600	250	100	525	150	150	-	1,775

* These observations were eventually dropped from the sample.

APPENDIX D

Table III

OTHER FIXED COSTS

Observation	Taxes	Ins.	Repairs	¼ Office Supplies	Telephone	½ Labor	¼ Acc't'g.	Misc.	Total
1	37	819	11,516	155	988	38,600	1,231	18,114	71,460
2	633	1,072	2,282	14	1,130	4,240	125	3,237	12,733
3	1,815	400	700	13	150	2,750	75	300	6,203
4	14	200	700	3	10	2,150	-	100	3,177
5	-	-	300	-	-	-	-	-	300
6	-	358	1,806	180	212	5,275	125	1,100	9,056
7	2,341	1,050	4,000	21	471	4,101	111	400	12,495
8	-	500	2,026	38	90	4,000	-	500	7,154
9	85	70	500	6	50	1,750	13	600	3,074
10	3	-	40	-	-	750	-	-	793
11	-	553	4,415	-	-	7,170	129	7,752	20,019
12	500	350	1,500	5	200	5,400	300	3,000	11,255
13	58	250	800	-	-	3,586	-	1,000	5,694
14	15	200	3,000	25	200	4,500	125	150	8,215
15	125	100	1,000	-	125	1,500	9	500	3,359
16	226	300	400	25	240	2,200	56	1,500	4,947
17	6	500	2,000	-	300	2,700	25	2,500	8,031
18	287	60	251	11	66	807	55	908	2,445
19	805	102	475	3	35	418	6	551	2,395
20	380	257	1,258	6	-	1,428	60	1,000	4,389
21	12	120	200	3	20	500	25	100	980
22*	1,526	167	5,936	5	77	6,910	50	3,672	18,343
23	33	163	400	-	43	-	-	1,020	1,659
24	199	68	897	-	39	644	-	685	2,532
25	325	775	128	3	20	1,920	50	1,200	4,421
26	250	800	1,000	25	1,000	4,000	125	100	7,300
27	20	45	300	-	36	750	6	400	1,557
28	12	50	200	-	50	250	9	-	571
29	250	40	1,000	-	125	1,750	-	-	3,165

Table III (continued)

Observation	Taxes	Ins.	Repairs	¼ Office Supplies	Telephone	½ Labor	¼ Acc't'g.	Misc.	Total
30	212	434	2,160	46	46	5,625	99	923	9,545
32*	1,200	-	3,300	530	1,279	15,000	450	500	22,259
33	800	235	500	13	300	1,000	75	1,500	4,423
34	3,738	3,573	8,401	-	666	9,901	287	6,229	32,795
35	165	100	200	5	50	1,000	13	1,200	2,733
36	192	300	3,000	125	-	9,000	175	4,000	16,792
37	150	534	1,655	50	36	4,903	150	3,233	10,711
39	525	117	1,000	13	200	5,000	19	300	7,174
40	297	140	1,009	51	451	5,365	203	2,319	9,835
41*	35	400	500	-	60	1,250	50	2,100	4,395
42*	550	477	2,979	177	635	6,020	395	2,769	14,002
43	58	200	1,562	44	55	2,350	13	2,300	6,582
44	474	100	289	13	36	2,000	75	420	3,407
45	-	100	500	25	240	5,400	200	1,000	7,465
46	130	75	200	-	25	1,050	25	500	2,005
48	20	50	100	-	25	300	-	1,000	1,495

*These observations were eventually dropped from the sample.

APPENDIX D

Table IV

VARIABLE COSTS

Observation	Elec.	Fuel	3/4 Office Supplies	Vet.	Drugs	½ Labor	3/4 Acc't'g.	Bedding	Total
1	3,429	16,830	464	3,493	12,696	38,600	3,694	425	79,631
2	675	5,326	43	-	1,755	4,240	375	160	12,574
3	400	1,000	37	80	1,700	2,750	225	1,300	7,492
4	60	500	7	35	500	2,150	-	600	3,852
5	-	-	-	60	665	-	-	1,200	1,925
6	545	1,827	360	400	1,319	5,275	375	-	10,101
7	2,385	3,795	63	1,386	700	4,101	333	4,000	16,763
8	1,080	525	112	411	80	4,000	-	-	6,208
9	400	200	19	50	400	1,750	37	750	3,606
10	140	-	-	150	35	750	-	100	1,175
11	4,711	2,103	-	815	-	7,170	386	-	15,185
12	1,200	1,200	15	100	2,400	5,400	900	2,000	13,215
13	500	125	-	300	1,700	3,586	-	1,500	7,711
14	200	850	75	200	1,900	4,500	375	2,500	10,600
15	200	1,000	-	50	2,500	1,500	26	1,000	6,276
16	200	1,200	75	-	1,200	2,200	169	-	5,044
17	350	3,000	-	200	1,300	2,700	75	3,000	10,625
18	194	567	34	65	366	807	165	300	2,498
19	117	481	9	90	220	418	19	150	1,504
20	492	835	16	188	-	1,428	180	404	3,543
21	150	500	7	30	50	500	75	700	2,012
22*	200	3,856	16	343	-	6,910	150	-	11,475
23	80	300	-	25	311	-	-	750	1,466
24	215	806	-	229	501	644	-	-	2,395
25	50	500	7	45	800	1,920	150	2,500	5,972
26	1,000	2,000	75	100	3,000	4,000	375	4,500	15,050
27	100	200	-	60	200	750	19	-	1,329
28	75	150	-	50	400	250	26	1,200	2,151
29	120	120	-	50	150	1,750	-	1,000	3,190

Table IV (continued)

Observation	Elec.	Fuel	3/4 Office Supplies	Vet.	Drugs	½ Labor	3/4 Acc't'g.	Bedding	Total
30	1,967	3,297	139	450	874	5,625	297	5,040	17,689
32*	1,900	-	1,590	-	-	15,000	1,350	-	19,840
33	730	80	37	250	650	1,000	225	2,000	4,972
34	3,533	9,720	-	1,212	-	9,901	861	3,000	28,227
35	200	50	15	500	600	1,000	37	1,000	3,402
36	1,200	1,500	375	1,850	-	9,000	525	4,000	18,450
37	428	-	150	250	1,407	4,903	450	3,000	10,588
39	1,000	3,000	37	1,500	-	5,000	56	500	11,093
40	488	200	153	-	120	5,365	607	-	6,933
41*	250	2,000	-	200	900	1,250	150	3,500	8,250
42*	2,397	1,680	531	-	-	6,020	1,186	2,400	14,214
43	360	643	131	-	3,148	2,350	37	3,715	10,384
44	180	365	37	300	600	2,000	225	832	4,539
45	1,100	1,700	75	100	3,500	5,400	600	4,000	16,475
46	240	10	-	100	40	1,050	75	1,500	3,015
48	200	200	-	-	100	300	-	1,000	1,800

*These observations were eventually dropped from the sample.

APPENDIX D

Table V

VARIABLE COSTS ADJUSTED TO 1.0 TURNOVER RATE

Observation	Turnover	Total Variable Cost	1.0 Turnover Var. Cost
1	2.4455	79,631	32,562
2	2.0	12,574	6,287
3	1.319	7,492	7,196
4	1.111	3,852	3,467
5	1.0	1,925	1,925
6	.6667	10,101	15,151
7	1.4286	16,763	11,734
8	.9292	6,208	6,681
9	.75	3,606	4,808
10	.5714	1,175	2,056
11	1.6667	15,185	9,111
12	2.0	13,215	6,608
13	2.761	7,711	2,793
14	1.8667	10,600	5,678
15	2.50	6,276	2,510
16	2.2727	5,044	2,219
17	2.143	10,625	4,958
18	1.9107	2,498	1,307
19	.92	1,504	1,635
20	1.77	3,543	2,002
21	1.033	2,012	1,948
22*	.525	11,475	21,857
23	.665	1,466	2,204
24	1.257	2,395	1,905
25	1.0	5,972	5,972
26	2.0	15,050	7,525
27	1.417	1,329	938
28	1.00	2,151	2,151
29	1.5569	3,190	2,049
30	1.8444	17,689	9,591
32*	1.25	19,840	15,872
33	2.0	4,972	2,486
34	2.0	28,227	14,114
35	2.298	3,402	1,480
36	1.4286	18,450	12,915
37	1.2	10,588	8,823
39	3.70	11,093	2,998
40	1.575	6,933	4,402
41*	.944	8,250	8,739
42*	1.902	14,214	7,473
43	1.95	10,384	5,325
44	1.0	4,539	4,539
45	1.750	16,475	9,414
46	1.412	3,015	2,135
48	2.0	1,800	900

APPENDIX E

APPENDIX E

Table I

TRUNCATED SAMPLE STRATUM - QUARTILES 1, 2, 3

1.0 TURNOVER RATE

	Total Investment	Cattle Fed	Fixed Costs	Variable Costs	Total Costs
Stratum I					
19	10,705	250	4,211	1,635	5,846
27	10,981	300	3,484	938	4,422
10	6,325	350	1,800	2,056	3,856
28	15,844	400	3,353	2,151	5,504
35	7,400	400	3,867	1,480	5,347
46	9,750	400	3,635	2,135	5,770
Total	61,005	2,100	20,350	10,395	29,745
Average	(10,168)	(350)			
Stratum II					
15	28,900	600	7,763	2,510	10,273
20	22,948	600	7,601	2,002	9,603
24	36,100	600	9,670	1,905	11,575
48	24,000	600	4,710	900	5,610
18	46,476	645	9,508	1,307	10,815
29	17,675	650	6,318	2,049	8,367
Total	176,099	3,695	45,570	10,673	56,243
Average	(29,349)	(616)			
Stratum III					
5	23,170	750	4,564	1,925	6,489
44	40,415	800	10,393	4,539	14,932
4	15,850	900	5,770	3,467	9,237
21	86,891	900	10,706	1,948	12,654
Total	166,326	3,350	31,433	11,879	43,312
Average	(41,582)	(838)			
Stratum IV					
13	44,532	1,000	13,121	2,793	15,914
23	35,820	1,000	7,714	2,204	9,918
39	10,500	1,000	8,954	2,998	11,952
16	42,680	1,100	11,867	2,219	14,086
14	29,450	1,200	12,615	5,678	18,293

Table I (continued)

	Total Investment	Cattle Fed	Fixed Costs	Variable Costs	Total Costs
Total	162,982	5,300	54,271	15,892	70,163
Average	(32,596)	(1,060)			
Stratum V					
43	30,775	1,400	10,374	5,325	15,699
12	48,500	1,500	17,040	6,608	23,648
37	47,000	1,500	16,831	8,823	25,654
2	31,609	2,000	17,739	6,287	24,026
26	68,000	2,000	18,260	7,525	25,785
40	53,017	2,000	16,594	4,402	20,996
45	61,150	2,000	15,829	9,414	25,243
Total	340,051	12,400	112,667	48,384	161,051
Average	(48,599)	(1,771)			
Stratum VI					
34	42,500	3,000	40,795	14,114	54,909
7	87,829	3,500	27,607	11,734	39,341
36	66,500	3,500	27,207	12,915	40,122
6	96,000	4,500	21,916	15,151	37,067
Total	292,829	14,500	117,525	53,914	171,439
Average	(73,207)	(3,625)			
Stratum VII					
1	155,300	10,000	94,283	32,562	126,845

APPENDIX E

Table II

TRUNCATED SAMPLE STRATUM - QUARTILES 1, 2

1.0 TURNOVER RATE

	Total Investment	Cattle Fed	Fixed Costs	Variable Costs	Total Costs
Stratum I					
27	10,981	300	3,484	938	4,422
10	6,325	350	1,800	2,056	3,856
28	15,844	400	3,353	2,151	5,504
35	7,400	400	3,867	1,480	5,347
Total	40,550	1,450	12,504	6,625	19,129
Average	(10,138)	(362)			
Stratum II					
15	28,900	600	7,763	2,510	10,273
20	22,948	600	7,601	2,002	9,603
48	24,000	600	4,710	900	5,610
29	17,675	650	6,318	2,049	8,367
Total	93,523	2,450	26,392	7,461	33,853
Average	(23,381)	(612)			
Stratum III					
5	23,170	750	4,564	1,925	6,489
4	15,850	900	5,770	3,467	9,237
Total	39,020	1,650	10,334	5,392	15,726
Average	(19,510)	(825)			
Stratum IV					
13	44,532	1,000	13,121	2,793	15,914
23	35,820	1,000	7,714	2,204	9,918
39	10,500	1,000	8,954	2,998	11,952
16	42,680	1,100	11,867	2,219	14,086
Total	133,532	4,100	41,656	10,214	51,870
Average	(33,383)	(1,025)			
Stratum V					
12	48,500	1,500	17,040	6,608	23,648
37	47,000	1,500	16,831	8,823	25,654

Table II (continued)

	Total Investment	Cattle Fed	Fixed Costs	Variable Costs	Total Costs
2	31,609	2,000	17,739	6,287	24,026
26	68,000	2,000	18,260	7,525	25,785
40	53,017	2,000	16,594	4,402	20,996
45	61,150	2,000	15,829	9,414	25,243
Total	309,276	11,000	102,293	43,059	145,352
Average		(1,833)			
Stratum VI					
34	42,500	3,000	40,795	14,114	54,909
7	87,829	3,500	27,607	11,734	39,341
36	66,500	3,500	27,207	12,915	40,122
6	96,000	4,500	21,916	15,151	37,067
Total	292,829	14,500	117,525	53,914	171,439
Average	(73,207)	(3,625)			
Stratum VII					
1	155,300	10,000	94,283	32,562	126,845

APPENDIX E

Table III

TRUNCATED SAMPLE STRATUM - QUARTILES 2, 3

1.0 TURNOVER RATE

	Total Investment	Cattle Fed	Fixed Costs	Variable Costs	Total Costs
Stratum I					
19	10,705	250	4,211	1,635	5,846
28	15,844	400	3,353	2,151	5,504
35	7,400	400	3,867	1,480	5,347
46	9,750	400	3,635	2,135	5,770
Total	43,699	1,450	15,066	7,401	22,467
Average	(10,925)	(362)			
Stratum II					
15	28,900	600	7,763	2,510	10,273
20	22,948	600	7,601	2,002	9,603
24	36,100	600	9,670	1,905	11,575
18	46,476	645	9,508	1,307	10,815
Total	134,424	2,445	34,542	7,724	42,266
Average	(33,606)	(611)			
Stratum III					
44	40,415	800	10,393	4,539	14,932
4	15,850	900	5,770	3,467	9,237
21	86,891	900	10,706	1,948	12,654
Total	143,156	2,600	26,869	9,954	36,823
Average	(47,718)	(867)			
Stratum IV					
13	44,532	1,000	13,121	2,793	15,914
16	42,680	1,100	11,867	2,219	14,086
14	29,450	1,200	12,615	5,678	18,293
Total	116,662	3,300	37,603	10,690	48,293
Average	(38,887)	(1,100)			

Table III (continued)

	Total Investment	Cattle Fed	Fixed Costs	Variable Costs	Total Cost
Stratum V					
2	31,609	2,000	17,739	6,287	24,026
26	68,000	2,000	18,260	7,525	25,785
45	61,150	2,000	15,829	9,414	25,243
Total	160,759	6,000	51,828	23,226	75,054
Average	(53,586)	(2,000)			
Stratum VI					
34	42,500	3,000	40,795	14,114	54,909
7	87,829	3,500	27,607	11,734	39,341
36	66,500	3,500	27,207	12,915	40,122
6	96,000	4,500	21,916	15,151	37,067
Total	292,829	14,500	117,525	53,914	171,439
Average	(73,207)	(3,625)			
Stratum VII					
1	155,300	10,000	94,283	32,562	126,845

APPENDIX E

Table IV

CALCULATION OF SHORT-RUN AVERAGE COST POINTS

QUARTILES 1, 2, 3

Stratum	I	II	III	IV	V	VI	VII
1.0 Turnover Rate							
Cattle Fed	2,100	3,695	3,350	5,300	12,400	14,500	10,000
Fixed Costs	20,350	45,570	31,433	54,271	112,667	117,525	94,283
Variable Costs	10,395	10,673	11,879	15,892	48,384	53,914	32,562
Total Cost	29,745	56,243	43,312	70,163	161,051	171,439	126,845
Av. Cost per Head	14.16	15.22	12.93	13.24	12.99	11.82	12.68
Av. Number Fed	(350)	(616)	(838)	(1,060)	(1,771)	(3,625)	(10,000)
3.0 Turnover Rate							
Cattle Fed	6,300	11,085	10,050	15,900	37,200	43,500	30,000
Fixed Costs	20,350	45,570	31,433	54,271	112,667	117,525	94,283
Variable Costs	31,185	32,019	35,637	47,676	145,152	161,742	97,686
Total Cost	51,535	77,589	67,070	101,947	257,819	279,267	191,969
Av. Cost per Head	8.18	7.00	6.67	6.41	6.93	6.42	6.40
Av. Number Fed	(1,050)	(1,848)	(2,514)	(3,180)	(5,313)	(10,875)	(30,000)

APPENDIX E

Table V

CALCULATION OF SHORT-RUN AVERAGE COST POINTS

QUARTILES 1, 2

Stratum	I	II	III	IV	V	VI	VII
1.0 Turnover Rate							
Cattle Fed	1,450	2,450	1,650	4,100	11,000	14,500	10,000
Fixed Costs	12,504	26,392	10,334	41,656	102,293	117,525	94,283
Variable Costs	6,625	7,461	5,392	10,214	43,059	53,914	32,562
Total Cost	19,129	33,853	15,726	51,870	145,352	171,439	126,845
Av. Cost Per Head	-	-	-	-	-	11.82	12.68
Av. Number Fed	(362)	(612)	(825)	(1,025)	(1,833)	(3,625)	(10,000)
3.0 Turnover Rate							
Cattle Fed	4,350	7,350	4,950	12,300	33,000	43,500	30,000
Fixed Costs	12,504	26,392	10,334	41,656	102,293	117,525	94,283
Variable Costs	19,875	22,383	16,176	30,642	129,177	161,742	97,686
Total Cost	32,379	48,775	26,510	72,298	231,470	279,267	191,969
Av. Cost Per Head	7.44	6.64	5.36	5.88	7.01	6.42	6.40
Av. Number Fed	(1,086)	(1,836)	(2,475)	(3,075)	(5,499)	(10,875)	(30,000)

APPENDIX E

Table VI

CALCULATION OF SHORT-RUN AVERAGE COST POINTS

QUARTILES 2, 3

Stratum	I	II	III	IV	V	VI	VII
1.0 Turnover Rate							
Cattle Fed	1,450	2,445	2,600	3,300	6,000	14,500	10,000
Fixed Costs	15,066	34,542	26,869	37,603	51,828	117,525	94,283
Variable Costs	7,401	7,724	9,954	10,690	23,226	53,914	32,562
Total Cost	22,467	42,266	36,823	48,293	75,054	171,439	126,845
Av. Cost Per Head	15.49	17.29	14.16	14.63	12.51	11.82	12.68
Av. Number Fed	(362)	(611)	(867)	(1,100)	(2,000)	(3,625)	(10,000)
3.0 Turnover Rate							
Cattle Fed	4,350	7,335	7,800	9,900	18,000	43,500	30,000
Fixed Costs	15,066	34,542	26,869	37,603	51,828	117,525	94,283
Variable Costs	22,203	23,172	29,862	32,070	69,678	161,742	97,686
Total Cost	37,269	57,714	56,731	69,673	121,506	279,267	191,969
Av. Cost Per Head	8.57	7.87	7.27	7.04	6.75	6.42	6.40
Av. Number Fed	(1,086)	(1,833)	(2,601)	(3,300)	(6,000)	(10,875)	(30,000)

APPENDIX F

APPENDIX F

Table I

CALCULATION OF AVERAGE INVESTMENT PER HEAD FED FOR STRATIFIED SAMPLE

Stratum	I	II	III	IV	V	VI	VII
Total Investment	74,105	255,819	201,809	270,822	439,725	292,829	155,300
1.0 Turnover Rate							
Total Cattle Fed	2,500	4,995	4,150	7,500	15,700	14,500	10,000
Average Investment	29.64	51.22	48.63	36.11	28.01	20.20	15.53
Average Number of Cattle Fed	357	624	830	1,071	1,744	3,625	10,000
1.5 Turnover Rate							
Total Cattle Fed	3,750	7,493	6,225	11,250	23,550	21,750	15,000
Average Investment	19.76	34.14	32.42	24.07	18.67	13.46	10.35
Average Number Cattle Fed	536	936	1,245	1,606	2,616	5,438	15,000
2.0 Turnover Rate							
Total Cattle Fed	5,000	9,990	8,300	15,000	31,400	29,000	20,000
Average Investment	14.82	25.61	24.31	18.05	14.00	10.10	7.76
Average Number of Cattle Fed	714	1,248	1,660	2,142	3,488	7,250	20,000
2.5 Turnover Rate							
Total Cattle Fed	6,250	12,488	10,375	18,750	39,250	36,250	25,000
Average Investment	11.86	20.48	19.45	14.44	11.20	8.08	6.21
Average Number of Cattle Fed	893	1,560	2,075	2,678	4,360	9,062	25,000

Table I (continued)

Stratum	I	II	III	IV	V	VI	VII
3.0 Investment Rate							
Total Cattle Fed	7,500	14,985	12,450	22,500	47,100	43,500	30,000
Average Investment	9.88	17.07	16.21	12.04	9.34	6.73	5.18
Average Number of Cattle Fed	1,071	1,872	2,490	3,213	5,232	10,875	30,000

APPENDIX F

Table II

CALCULATION OF AVERAGE INVESTMENT PER HEAD FED
FOR TRUNCATED SAMPLE STRATUM - QUARTILES 2, 3

Stratum	I	II	III	IV	V	VI	VII
Total Investment	43,699	134,424	143,156	116,662	160,759	292,829	155,300
1.0 Turnover Rate							
Cattle Fed	1,450	2,445	2,600	3,300	6,000	14,500	10,000
Average Investment	30.14	54.98	55.06	35.35	26.79	20.20	15.53
Average Number of Cattle Fed	362	611	867	1,100	2,000	3,625	10,000
1.5 Turnover Rate							
Total Cattle Fed	2,175	3,668	3,900	4,950	9,000	21,750	15,000
Average Investment	20.09	36.65	36.71	23.57	17.86	13.46	10.35
Average Number of Cattle Fed	543	916	1,300	1,650	3,000	5,438	15,000
2.0 Turnover Rate							
Total Cattle Fed	2,900	4,890	5,200	6,600	12,000	29,000	20,000
Average Investment	15.07	27.49	27.53	17.68	13.40	10.10	7.76
Average Number of Cattle Fed	724	1,222	1,734	2,200	4,000	7,250	20,000
2.5 Turnover Rate							
Total Cattle Fed	3,625	6,112	6,500	8,250	15,000	36,250	25,000
Average Investment	12.05	21.99	22.02	14.14	10.72	8.08	6.21
Average Number of Cattle Fed	905	1,528	2,168	2,750	5,000	9,062	25,000

Table II (continued)

Stratum	I	II	III	IV	V	VI	VII
3.0 Turnover Rate							
Total Cattle Fed	4,350	7,335	7,800	9,900	18,000	43,500	30,000
Average Investment	10.04	18.33	18.35	11.78	8.93	6.73	5.18
Average Number of Cattle Fed	1,086	1,833	2,601	3,300	6,000	10,875	30,000

APPENDIX G

APPENDIX G

Cattle Feeding in Alberta

A Production Economics Study

STRICTLY CONFIDENTIAL

Questionnaire # 1

Census District 2

(To be completed by interviewer)

Name ______________________________

Mailing address ______________________________

Telephone number ______________________________

Telephone exchange ______________________________

Legal description of quarter on which feedlot is located

Quarter ________ Sec. ________ Tnsp. ________ Range ________

General Information

1. Indicate the most recent twelve month period for which records of feedlot information are available.

   1) ☐ Calendar year: 1966

   2) ☐ Fiscal year: 1965-1966 → 3

   3) ☐ Fiscal year: 1966-1967

   Use of records for the period checked above will be of great assistance in the remainder of the questionnaire.

2. Total acres used:

   a) As a feedlot site. → 4

   b) As pasture or field specifically for feeder cattle use and independent of any other farm or ranch operation. → 5

General Breed Data

3.

Types of Cattle	Percentage of each type fed	Average daily gain of each type
British breeds and crosses	6	7
Charolais breed and crosses	8	9
Holstein breed and crosses	10	11
Other dairy and beef breeds and crosses	12	13
	Total = 100%	

Sex Data

4.

Class of cattle	Percent of each type fed	Average daily gain of each class
Bulls	14	15
Steers	16	17
Heifers	18	19
Cows	20	21
	Total = 100%	

General Physical Data

5. What is the maximum feedlot capacity (in numbers of animals) at any one time? 22

6. During the most recent twelve month accounting period:

a) Total number of cattle fed was 23

b) Maximum numbers of cattle on feed at any one time during the accounting year were: 24

c) The peak feeding periods lasted from:

1) ______________ to ______________

2) ______________ to ______________
(month) (month)

To be completed by interviewer

25
26
27
28

d) What were the reasons for the peaks occurring when they did?

____

____

____

____

To be completed by interviewer

29
30
31
32

e) Minimum number of cattle fed at any one time during the last accounting year was: 33

f) The slack feeding period lasted from:

______________ to ______________
(month) (month)

To be completed by interviewer

34
35

Note: Percentages entered in 7a and 7b must total 100%.

7. a. Cattle Owned by the Feedlot Operator

Percentages of the total number of cattle fed during the most recent accounting period that were:

a) Grown on a ranch operated with the feedlot. — 36

b) Purchased direct from other ranches or farms. — 37

c) Purchased at local auction markets. — 38

d) Purchased at a terminal market. — 39

e) Purchased through other agent. — 40

Describe other agents ________. → To be completed by interviewer. — 41

b. Cattle Fed on a Custom Basis

Percentages of the total number of cattle fed during the most recent accounting period for:

a) Farmer stockmen. — 42

b) Speculators. — 43

c) Packers. — 44

d) Ranchers. — 45

e) Livestock dealers. — 46

f) Commission firms. — 47

g) Others. — 48

Specify others ________. — 49 Total=1

→ To be completed by interviewer — 50

Cattle Sales

8. Of the cattle leaving the lots what percent was sold:

a) Direct to a major packing plant. — 51

b) Through terminal auction markets. — 52

c) Through community livestock auctions. — 53

d) To order buyers or other brokers. — 54

e) To small independent slaughter plants. — 55

f) To others. — 56

Specify others ________ — 57 Total=1

→ To be completed — 58

Capital Investment Items

Note: "Annual Depreciation for Tax Purposes" - is the depreciation actually claimed

in the previous accounting period for tax purposes.

9.

Capital Investment In:	Historical or original cost	Accumulated depreciation	Amount of annua depreciation claimed for tax purposes
Land (feedlot site and pasture used with lot)	59	60	61
Buildings used for living accommoda-tion (exclude owners' dwellings)	62	63	64
Buildings used for storage, hospital purposes or livestock shelters	65	66	67
Pens and livestock feeders (including any concrete feeding surfaces)	68	69	70
Water-wells, pipe and watering equipment	71	72	73
Trucks, tractors, semi-trailers, etc.	74	75	76
STATIONARY FEEDLOT EQUIPMENT (eg. livestock and truck scales, roller and hammermills, stationary blenders, squeeze chutes, fixed augers or conveying equipment, etc.)	77	78	79
PORTABLE FEEDLOT EQUIPMENT (eg. feed wagons, manure spreaders, movable augers and conveyers, small trailers, etc.)	80	81	82
All Other Capital Items	83	84	85
TOTAL	86	87	88

Other Non-Feed Costs

10.

Cost Item	Annual amount paid
a) Taxes (land, buildings, etc.)	89
b) Insurance (buildings, livestock, machines)	90
c) Electricity	91
d) Gas and oil	92
e) Machinery and equipment repairs	93
f) Office supplies	94
g) Veterinary fees	95
h) Drugs and implants	96
i) Telephone	97
j) Labor	98
k) Accounting and bookkeeping	99
l) Trucking, commission and like charges	100
m) Bedding	101
n) Other costs (manure and snow removal, small tools, etc.)	102
TOTAL	103

Feeding Program

11. Typical Feeding Results for the Most Recent Accounting Year (complete table row by row)

Class of animals fed	Average starting weight of the class	Number of cattle starting in this class	Number of cattle lost through death at the indicated times during the feeding period			Average finishing weight of the class	Percentages of each cla of cattle at the end of the feeding period that graded		
			start	middle	end		choice	good	less th good
Calves	104	105	106	107	108	109	110	111	112
Light feeders	113	114	115	116	117	118	119	120	121
Heavy feeders	122	123	124	125	126	127	128	129	130

12. Source of Typical Ration Components for the Most Recent Accounting Year (complete this table row by row)

	Feed components	Total amount of each component fed	Total cost of each component	Percent of each component that was: home grown	bought from growers	bought from a commercial feed source
feed concentrate	Complete commercial feed	131	132	133	134	135
	Feed grains	136	137	138	139	140
	Crop by-products	141	142	143	144	145
supplements	Complete commercial supplement	146	147	148	149	150
	Home blended supplement	151	152	153	154	155
roughage	Hay	156	157	158	159	160
	Chopped roughage (haylage, silage, etc.)	161	162	163	164	165
	Pasture	166	167	168	169	170

List, in order of importance, the feed grains used in rations.

____

____

List, in order of importance, the crop by-products used in rations.

____

____

List, in order of importance, the different types of chopped roughage used in rations. ____________________

____

____

To be completed by interviewer

171
172
173
174
175
176
177
178
179
180

Ration Formulation and Feeding

13. Percentages (by weight) of Feed Ingredients in the Ration (complete table column by column)

Feed ingredient	Percent of each ingredient used in each ration		
	growing ration	starting or warming ration	finishing ration
Feed grains	181	182	183
Crop by-products	184	185	186
Commercial supplement	187	188	189
Home blended supplement	190	191	192
Hay	193	194	195
Chopped roughage	196	197	198
Pasture	199	200	201
	Total=100%	Total=100%	Total=100%

14. Typical amounts of feed fed per day per head at beginning and end of period during which each ration was used. (complete table row by row)

Class of livestock	Average pounds of feed fed per head per day of:					
	growing ration		starting ration		finishing ration	
	beginning of feed period	end of feed period	beginning of feed period	end of feed period	beginning of feed period	end of feed period
Calves	202	203	204	205	206	207
Light feeders	208	209	210	211	212	213
Heavy feeders	214	215	216	217	218	219

Physical Facilities and Operation

15. a) Total number of pens. → 220

b) Total acreage of pens. → 221

c) Average number of pens in use at one time. → 222

d) Principal reason for leaving any pens idle (check).

1) ☐ Low fat cattle prices or high feeder prices
2) ☐ Disease prevention
3) ☐ Others (specify) ______________

To be comp by intervi

223

e) Principal construction materials used for pen fences.

____ To be completed by interviewer 224 225 226

f) Surfacing in the pens (eg. earth, concrete, etc.)

____ To be completed by interviewer 227 228 229

Natural and Artificial Shelter

16. From which directions does the feedlot require protection from the elements?

1) ☐ N 3) ☐ E 5) ☐ NE 7) ☐ NW

2) ☐ S 4) ☐ W 6) ☐ SE 8) ☐ SW

To be completed by interviewer 230 231

17. If feedlot is sheltered by <u>natural barriers</u>, what type of shelter is provided? 232

(eg. valley, shelterbelt, etc.) 233

1. ____

2. ____

3. ____

4. ____

To be completed by interviewer 234 235 236 237

18. If windbreak fences used:

a) Percentage of windbreak fences integrated into pen walls? 238

b) Percentage of windbreak fences not integrated into pen walls? 239

c) Type windbreak fences: (check one or more)

1. ☐ Solid

2. ☐ Slatted

3. ☐ Other (describe) ____________________

240 To completed interviewer 241

d) Construction materials used in windbreak fences:

1. ☐ Wood slats

2. ☐ Plywood

3. ☐ Other (describe) ____________________

242 To completed interview 243

e) Average height (in feet) of the windbreak fences: 244

19. Barns, Sheds, or Other Structures Used for Shelter and Hospital Facilities for Sick Animals

Type of shelter (eg. barn, shed, etc.)	No. of units on the place	No. of sides enclosed by the shelter	Major construction materials	Dimensions			Roof shape (draw roof outline in the box)	Type of flooring (eg. earth, concrete, asphalt, etc.)	Coding section: to be completed by interviewer only.								
				lgth.	depth	ht.			T	NU	NS	CM	L	D	H	RS	TF
									245	246	247	248	249	250	251	252	253
									254	255	256	257	258	259	260	261	262
									263	264	265	266	267	268	269	270	271
									272	273	274	275	276	277	278	279	280
									281	282	283	284	285	286	287	288	289
									290	291	292	293	294	295	296	297	298

Feedlot Storage for Feed Materials

20. Approximate amount of permanently roofed storage space available for:

a) Feeds and supplements is: (tons) → 299

b) Roughages is: (tons) → 300

21. During the most recent accounting period when did you buy feeds? (complete table row by row in percentage terms.)

Feed class	As needed	At harvest	Whenever prices were low	Total
Complete commercial feed	301	302	303	100%
Feed grains	304	305	306	100%
Crop by-products	307	308	309	100%
Complete commercial supplement	310	311	312	100%
Components for home blending of supplements	313	314	315	100%
Roughage	316	317	318	100%

22. List types of storage structures at the lot site (eg. grain storage buildings, silos, hay sheds, etc.)

____

____

____

____

____

____

To be completed by interviewer

319
320
321
322
323
324
325
326
327

Feeding Methods

23. a) Types of GRAIN FEEDERS used:

1. Fenceline bunk feeders

Construction materials ______________________________

____

To be completed interviewer

328
329

Total trough length for the lot of this type of feeder (ft.) → 330

Frequency of filling (times/day) 331

How the feeder is filled ____________________ To be completed by interviewer 332

____

Trough length of bunks used in feeding cattle on pasture

(if applicable) (ft.) 333

b) BUNK FEEDERS (non-fenceline type)

Construction materials ____________________ To be completed by interviewer 334 335

____

Total trough length (in feet) of this type of feeder used in feedlot. 336

Frequency of filling (times/day) 337

How is the trough filled ____________________ To be completed by interviewer 338

____

Total trough length (in feet) of bunks used in feeding cattle

on pasture (if applicable) (ft.) 339

c) SELF-FEEDERS

Construction materials ____________________ To be completed by interviewer 340 341

____

Capacity of an average feeder (in tons) 342

Number of self-feeders 343

Average trough length per feeder (ft.) 344

Number of self-feeders used to feed cattle on pasture 345

24. If some roughage is fed in other than grain feeders describe the type of roughage feeder used.

Type of feeder	Construction materials	How feeder is filled (if applicable)	Frequency of feeding (times/day)	Total length of feeders	Code Section - to b[e] completed by interv[iewer] feeder code	constr. code	
			346	347	348	349	35
			351	352	353	354	35
			356	357	358	359	36

Feed Formulation and Transport Equipment

25.

	Equipment name	No. of units of this equipment	Capacity (units/hr) of each unit	Equipment c to be compl by intervie
Feed mill equipment (eg. roller, hammer mills, blenders, etc.)		361	362	363
		364	365	366
		367	368	369
		370	371	372
		373	374	375
Distribution equipment (eg. feed trucks, feed wagons, conveyers, etc.)		376	377	378
		379	380	381
		382	383	384
		385	386	387
		388	389	390
		391	392	393
		394	395	396
		397	398	399

Labor

26. Hired Feedlot Labor Used During Most Recent Accounting Period (Exclude time of the manager or managers).

a) Total number of full-time workers → 400

b) Average hours worked per day per worker (full-time staff) → 401

c) Part-time labor

Months worked		Number of workers	Average hrs. worked per worker per day
month	to month		
402	403	404	405
406	407	408	409
410	411	412	413

Custom Charges

27. If cattle are fed on a custom basis, list: (if applicable)

a) Charge per ton of:

- growing ration → 414
- starting ration → 415
- full feed or finishing ration → 416

b) Daily yardage charges → 417

c) Other charges (list amount and describe basis of each charge)

____
____
____
____
____
____

To be completed by interviewer → 418 419 420 421 422

Health and Sanitation

28. How are veterinary services provided? (check one)

a) ☐ By contract with a veterinarian

b) ☐ By calling a veterinarian when animals appear to need special attention.

To be completed by interviewer → 423

29. How often are cattle inspected for health? (times per day) → 424

30. What procedure is followed in making health inspections?

____
____
____

To be completed by interviewer → 425 426 427

31. a) Describe how manure and snow are removed from the lot.

____
____
____
____

To be completed by interviewer → 428 429 430 431 432

b) Number of times per year pens are given a general cleaning. → 433

c) Are the cattle pens graded for drainage? (check one)

1) ☐ No 2) ☐ Yes → To be completed by interviewer → 434

32. Use of bedding

Type of bedding used	Months bedding was used: month	to month	Tons of bedding used	Bedding code - to be completed by interviewer
	435	436	437	438
	439	440	441	442
	443	444	445	446
	447	448	449	450

33. Does the feedlot have livestock scales (check one)

1) ☐ No 2) ☐ Yes → To be completed by interviewer → 451

34. Does the feedlot have truck scales (check one)

1) ☐ No 2) ☐ Yes → To be completed by interviewer → 452